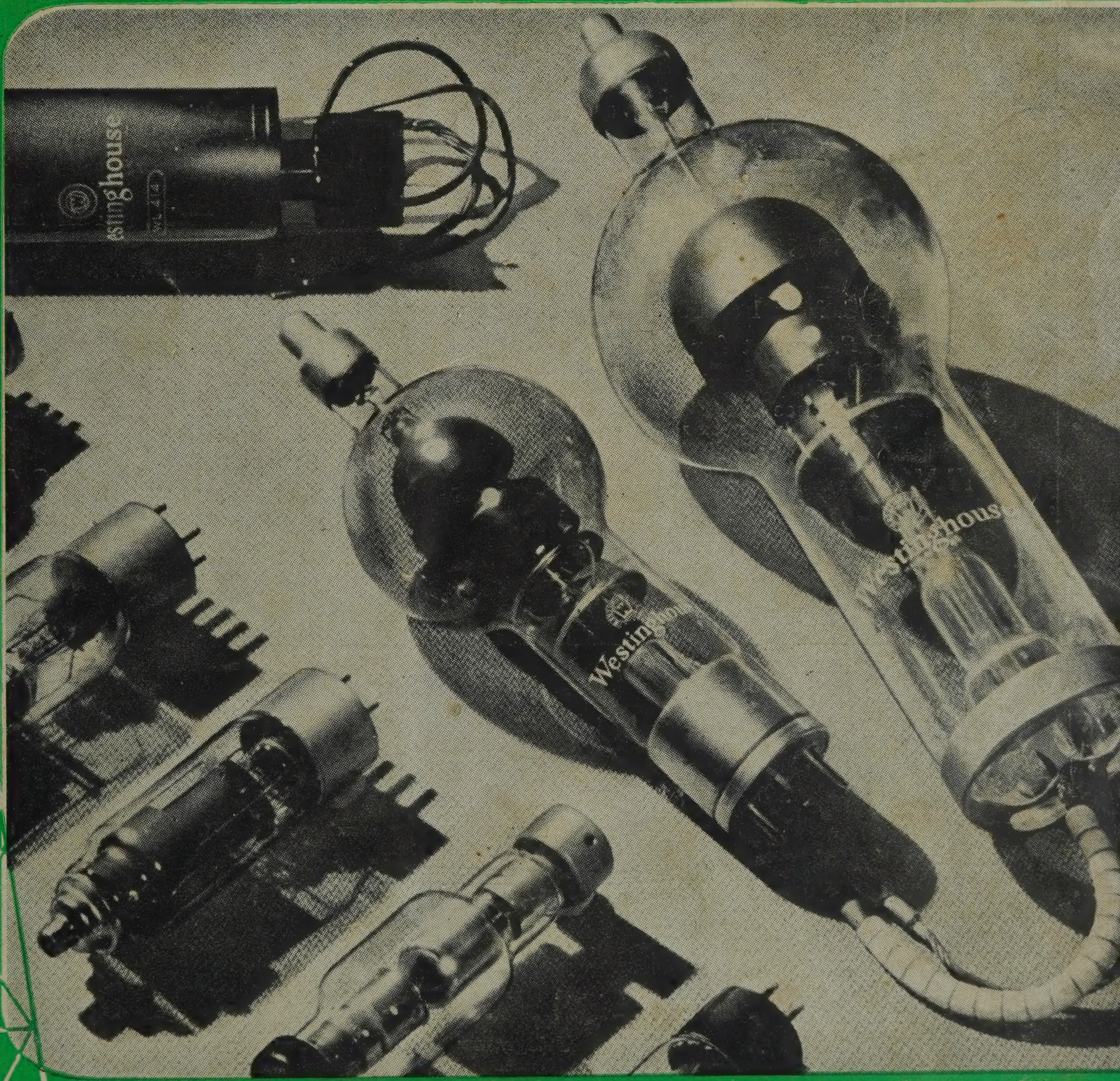
RADIO and ELECTRONICS



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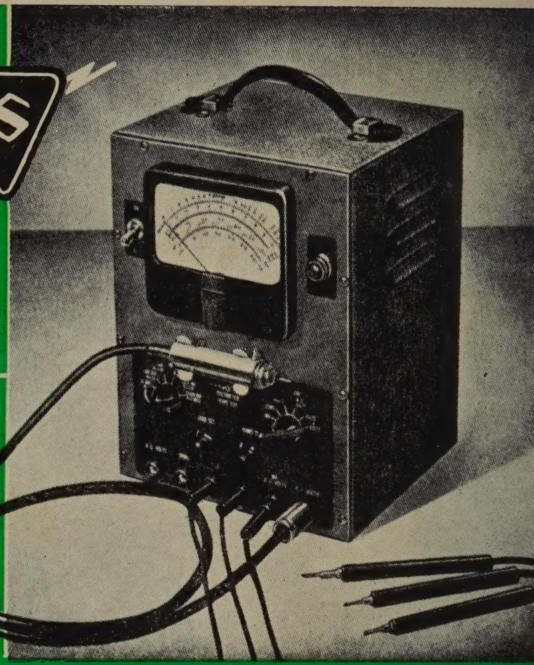

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"RADIO AND ELECTRONICS," VOL. 2

As we have now commenced our second volume we will, in our next issue, print a complete index of Volume 1.

Published for the proprietors by FEATURE PRODUCTIONS, P.O. Box 5065, Wellington.

THE SECOND YEAR

With this issue, *Radio and Electronics* embarks upon the second year of its career. This time a year ago the second world war was not long over, and it was thought an opportune time for the inauguration of a periodical devoted to radio. Such a publication, we felt, if planned along the right lines, should fill a long standing gap in the radio and electronic activities of this country.

That there was a need for a technical journal, and for a vehicle through which news of the radio industry could be disseminated, is no longer in question. This was amply proven by the enthusiastic and cordial welcome which was accorded us from the outset by all the radio-interested public.

First of all, the Editors of this journal would like to extend their thanks for all the letters of appreciation which have been received since the first issue made its appearance. These letters, together with the oral approbation received from so many of our readers, have given us great encouragement in what must always be the most difficult period of a publication—namely, its first twelve months.

As we stated a year ago, it has been our aim to produce something which would be of interest to all those who are concerned with radio, either as a livelihood, or as a hobby. We realised that this was a difficult task, and that it is patently impossible to please all of our readers all the time, but judging by the letters and complimentary remarks referred to above, we have succeeded beyond what was thought possible. We set out to cater, if possible, for all tastes, and we have received commendation from such diversified sources as university professors and schoolboys.

To that extent, perhaps, we can feel justly proud; but there are several points of which we must not lose sight. One of these is that those who disapprove, in whole or in part, of *Radio and Electronics* very rarely, if ever, go to the trouble to tell us so. Nor are we so satisfied with our own efforts as to think that they cannot be bettered. Undoubtedly they can, and it will be our constant endeavour to see that they are.

Naturally, we have our own ideas on this subject, and these are being acted upon. For example, from the outset it was realised that authoritative technical information necessitates not only the consultation of world authorities *via* their writings, but on the practical side, much experimental work must be undertaken. To that end, we have set up our own laboratory, which at the present juncture is in the throes of an expansion programme which, we hope, will make it one of the best equipped of its type in the country. It has been, and still is, our aim to provide for our readers the most up-to-date information, not only on technical matters, but on subjects affecting the radio industry as a whole.

That these aims are good there is no gainsaying, but how far we succeed in them is very difficult for us to estimate. For this reason, we would urge any or all of our readers who have suggestions as to the manner in which *Radio and Electronics* could be improved, to submit them to us, for they will be gratefully received and carefully considered. We want to give readers the types of article they desire, and it is only by suggestion and constructive criticism that we can tell if this is being done.

At this date, we feel proud and grateful that we have been accepted with such readiness by the radio industry, and by technical people throughout New Zealand, for it is their support which has made *Radio and Electronics* possible. In this ensuing year, we are confident of retaining that support, and in producing a bigger and better *Radio and Electronics* containing only the most authoritative technical and commercial material concerning the rapidly expanding world of electronics.

Frequency Standard at Electronics Department, Canterbury University College

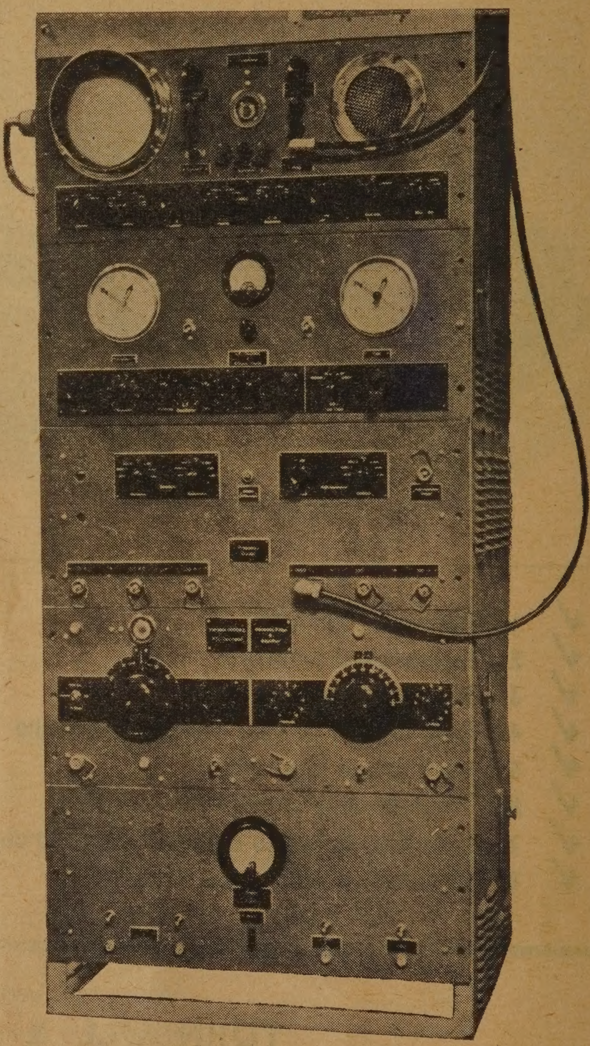
By Professor T. R. Pollard, Canterbury University College.

This frequency standard owes its development and construction to the Electronics Scholarship students at Canterbury University College. The first work was done by Mr. P. W. Humphries, the Electronics Scholarship holder for 1944. It comprised the major piece of work for Mr. Humphries for his post-graduate year. Considerable progress was made in this year, and the work was carried on by the next scholarship holder, Mr. I. Lowe, during 1945. Although this did not form the major portion of Mr. Lowe's work, sufficient was done to get the job operating and to check on its performance. Further work was done in 1946 by Mr. Drummond and Mr. Lever-Naylor, the Electronics Scholarship holders of that year. Mr. Drummond was responsible for the precision oven and its associated crystal oscillator, and Mr. Lever-Naylor was responsible for the development and construction of the harmonic filter.

When this frequency standard was first considered, a certain amount of emphasis was placed on the accurate determination of the low frequencies from 50 cycles up, but, as work progressed, it was decided to try to design the apparatus to operate with the same accuracy into the megacycle frequencies. In 1944 the only crystal standard available was a 1000 K.C. variable air gap and oven. It was decided to use this, and, at some later date, to use something with a higher degree of accuracy. It was realised that a 100 K.C. bar would have higher stability, but, at that time, nothing was available.

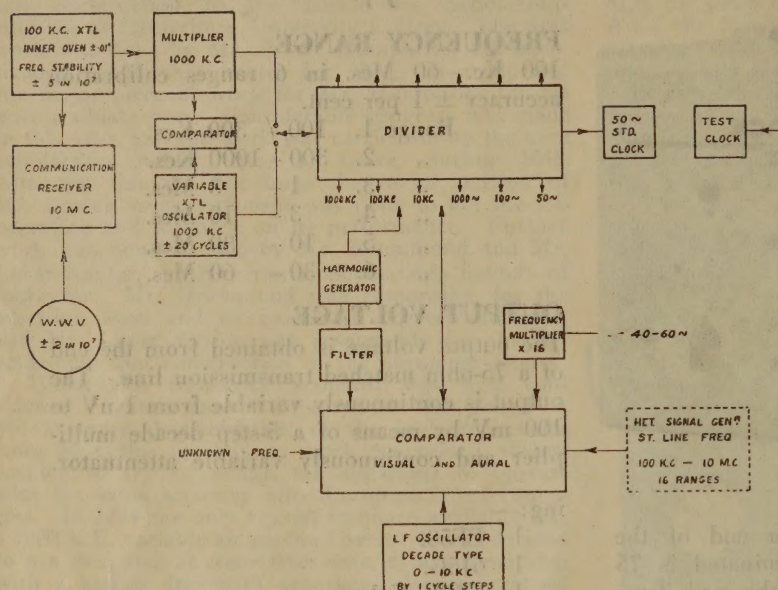
Block diagram No. 1 shows the layout of the frequency standard as it is at present. There is first the 100 K.C. crystal oscillator with its precision oven control and associated multiplier. The crystal unit is a specially selected bar mounted in a vacuum. The glass container is quite small, about $\frac{5}{8}$ in. diameter and 3 in. long. The circuit used is a standard Pierce using a 6SJ7. The oven control for this crystal is done in two stages. The outer oven approximately 8 in. x 4 in. x 6 in. has a 50-watt heating element, operated off A.C., controlled by a thyratron, the grid of the thyratron being in turn controlled by a conventional bimetallic strip contact. The differential of this contact was about 1°C. On investigation, the heat flow in the oven showed the necessity for placing an anticipating auxiliary heater element near the bimetallic strip. With this in operation the outside portion of the inner precision oven was kept at a temperature of 45°C. so that the wattage required for this inner oven is quite small, in the nature of one or two watts. This made possible the use of an ordinary 6L6 valve as a suitable control.

Block diagram No. 2 shows the method of control, a bridge consisting of four resistances supplied with 50-cycle A.C. at about 10v. Three arms of this bridge consist of zero temperature coefficient wire, the fourth arm of copper wire. The copper arm resistance is wound adjacent to the heating element for this inner oven, the oven itself being a $\frac{3}{4}$ in. tube, 4 in. long. The output from the bridge gives approximately .2v. per degree centigrade change. This, in turn, is amplified and used to control the grid of the 6L6, the plate of which is supplied by 50-cycle 400v. A.C., the heating element of the inner oven being placed in series with the plate. The use of A.C. in this manner allows the sign of the bridge, positive or negative, to be used to control the current into the heater above or below a chosen operating point. The main difficulty was experienced in getting accurate records of inner oven temperature. It is known that the temperature variation is less than $^1/_{100}$°C.,



Frequency Standard at Canterbury University College.

but may be operating much closer than this. All the elements in this inner oven had to be put through a number of fairly wide range heat cycles to stabilise everything. The high tension supplied to the oscillator is electronically stabilised. The multipliers are conventional, doubling in the first stage and five times in the second, with two tuned circuits in the latter. A special 10 pf. trimming circuit is used on the crystal which can be readily adjusted to WWV operating on 10 m.c. to about 1 cycle.



FREQUENCY STANDARD
ELECTRONICS DEPARTMENT
CANTERBURY COLLEGE

FIG. 1.

During the first month of operation a certain amount of drift was experienced in the order of 5 cycles. At present, checks on WWV show it to hold within 2 or 3 cycles in 10 million. This portion of the equipment is situated high up on the stone walls of the Electronics Laboratory and runs continuously (except in the case of a power failure). The 1 m.c. output of the multiplier is connected to the divider stage chassis by microphone cable. The divider chassis does not use multi vibrators, but uses a method of mixing, first used, I think, by the Bell Telephone Company.

Block diagram No. 3 shows the method. One of the disadvantages of the multi vibrator divider is that if, for any reason, the crystal oscillator stops, the multi vibrator can run wild. This is not possible with the method adopted. It will be appreciated that for satisfactory performance the nine times multiplying circuit must have a high Q. This was readily attained in the higher frequencies, but difficulty was experienced at 900 cycles and was not overcome until some special powdered iron core toriods were wound. The various frequencies obtainable are shown on block diagram No. 1, 1v. being obtainable with a generator impedance of about 100 ohms. This low impedance makes it readily available for sending over coaxial lines. A single high impedance supply, giving about 50v., is also available, but only one frequency at a time can be selected. The harmonic generator selects any one of the frequencies, distorts by considerably overloading an amplifier and makes use of a wide range filter (from 1 k.c. to 10 m.c.) to select any of the harmonics desired.

The comparator chassis is a little more complicated. Provision has been made for using various methods of comparison. The C.R.O. is of the 5 in. type with its V and H amplifiers designed to operate over a wide band of frequencies from a few cycles up to a megacycle or more. The design of the amplifiers was troublesome, but, once again, they were required to operate from a few cycles to over 1 m.c. Hum was a problem; a great deal of filtering had to be employed to get rid of the 100-cycle ripple, which, owing to the low frequency response of the amplifiers, was readily passed on. 6AC7 and 6AG7 valves were used in this part of the circuit.

1. The first method of comparison allows the unknown frequency to be compared directly as a Lissajou figure with any of the standard frequencies.

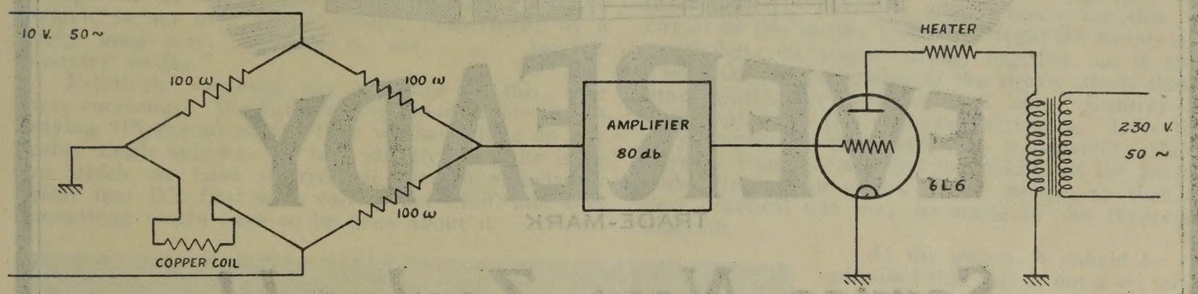
2. Direct comparison, but using a circular time base from the standard frequency selected and using the introduced frequency as grid modulation. A fair amount of trouble was experienced in designing a circular time base to operate on the six standard frequencies, 50 cycle to 1 m.c. This method of comparison has, in certain cases, an advantage over the first method, especially where fractional patterns are being used.

3. Comparison by frequency difference. In this case the standard frequency was fed to one grid of a mixer valve, and the frequency undermeasurement to the other grid. The difference frequency is fed to the vertical deflection plates of the C.R.O., a suitable filter being selected to cut out the higher frequencies. The horizontal plates of the C.R.O. are fed from a special L.F. oscillator and thus the difference frequency measured. A modification of this method consists of taking a harmonic of the standard frequency from the harmonic generator and filter and feeding this to the mixer valve, and thus it is possible to work on comparatively small frequency differences.

4. For this comparison of frequencies near 50 cycles, two clocks are available, one fed from the 50-cycle standard and one with its associated amplifier from the nominal 50 cycle under test.

5. To allow fairly accurate determinations of frequencies near the power frequency of 50 cycles (actually 40 to 60 cycles) a frequency multiplying circuit is used of the non-resonant type giving a multiplying factor of 16. Thus a nominal 50 cycles becomes 800 cycles, which, in turn, is compared with

the eighth harmonic of the 100-cycle standard output. A small speaker is also fed from the output of the mixer and used in conjunction with the C.R.O. Such a speaker is essential for working in wide ranges of difference frequencies. The L.F. oscillator is somewhat unusual, it being an R.C. type oscillator with R as the variable. Actually a conductance bridge was built and there are four decade dials giving a range of frequency from 1 to 10,000 to 1-cycle increments. These decades in turn can be checked against for performing the various types of frequency comparison. The magic eye indicator in the centre is used for measuring beats independent of the C.R.O. It is really in parallel with the speaker. A space above the present top chassis is available in the rack, and here will be placed the straight line frequency heterodyne wavemeter. This is at present under construction and consists of a special straight line frequency condenser with a 16-turret coil selector allowing a frequency coverage from 100 k.c. to 10



HEATER CONTROL
FIG 2

the standard frequency. Thus it is possible to determine different frequencies to an accuracy of one or two cycles.

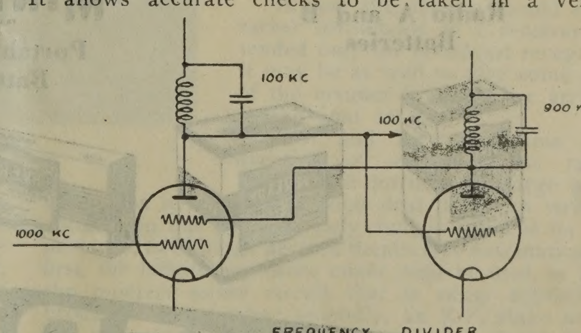
When dealing with frequencies that are very close to the standard frequency, say 1000 K.C. crystal within 5 or 10 cycles, it is very difficult to determine whether the frequency being checked is fast or slow. To overcome this difficulty, a separate 1000 K.C. crystal is used. Actually, the 1000 K.C. oven first mentioned is used, the crystal being shunted by about 20 pf. variable condenser. This allows the oscillator to be adjusted to about 20 cycles fast or 20 cycles slow. Provision is made for a mixer valve and a magic eye in order to zero this variable frequency crystal against the standard. Provision is also made to switch the complete divider from the standard to the variable crystal oscillator and thus, by shifting the variable crystal oscillator dial, one is able to determine whether the frequency under measurement is fast or slow. This device works out very well in practice and is a very necessary adjunct to such a standard.

The photograph shows the general layout of the frequency standard. The bottom panel and chassis contain the various power supplies regulated and unregulated. The next chassis up contains, on the left, the variable crystal standard with its frequency dial and magic eye indicator. On the right is the harmonic generator and its wide range filter. The next chassis up contains the frequency divider and the various frequency coaxial outlets. On the left are the switches for selecting standard frequencies up to the comparator, and on the right is the high impedance standard frequency outlet and selector. The next chassis up contains the clocks with their amplifiers and the decade low frequency oscillator. On the right is the input for the nominal 50-cycle frequency multiplier. The top chassis is the comparator chassis and shows on the left the 5 in. C.R.O. with 1000-cycle circular time base in operation modulated by a 10 K.C. voltage. In the right is the small speaker and below are the various selector switches

m.c. in small ranges. It will be used as an interpolation oscillator, hence the straight line frequency characteristic. A special mechanical dial arrangement will be provided to allow easy interpolation.

Normally this rack portion of the frequency standard is switched off. After switching on it is operative within about two minutes, but the variable frequency crystal oscillator takes about 15 minutes to reach its operating temperature. A slow drift is experienced in the low frequency oscillator over about the first hour of warming up, but, as this oscillator is self-checked, no trouble is experienced as the drift is small and quite slow.

A great deal of experimental work was done in connection with the development of this frequency standard, but the final result is well worth while. The standard is very versatile and easily operated. It allows accurate checks to be taken in a very



FREQUENCY DIVIDER
FIG 3

short time. Auxiliary apparatus is being constructed to extend its frequency coverage up to 1000 m.c.

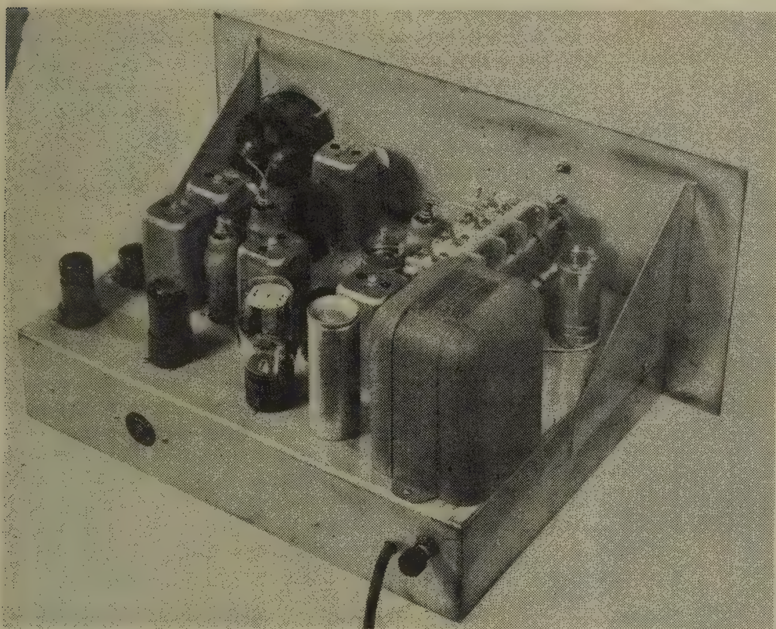
On behalf of the Electronics Department, Canterbury College, I wish to thank the students and the staff who work on this instrument and also to acknowledge the various helpful suggestions from the D.S.I.R. developmental section working at Canterbury University College.

THE RADEL DX BROADCAST 12

This article describes the design and construction of a 12-tube broadcast receiver intended to give the best possible results on DX reception. Through the use of recent circuit developments, an unusually good signal/noise ratio has been achieved.

Several months ago (in the September, 1946, issue, to be exact) *Radio and Electronics* signified its willingness, should sufficient interest be displayed, to design for broadcast band DX enthusiasts a receiver which, in our own words, would "outperform, by a very long way, anything in use . . . in this country to-day."

Relatively speaking, the response to this offer was enormous! We have received many more letters saying "Please go ahead" than we have done on any other single subject. In fact, shortly after the issue to which we have referred, it became abundantly clear that DX fans were calling our bluff, and that something would have to be done about it.



Top chassis illustration of Broadcast 12.

Here, then, is the result of much deliberation, and no little experimental work. In arriving at the final design, all suggestions from readers were considered, along with our own ideas on the subject, and no feature which was felt to be indispensable was omitted. Naturally, in evolving such a set, there is much room for individual preference, and the ideas of a few are not necessarily those of everyone, but making due allowance for this fact, it was felt that the present design would meet the requirements of most of our interested readers.

OUTLINE OF THE SET

Since the purpose of this article is to describe how the results obtained with the laboratory model may be duplicated, and because this receiver is a good deal more ambitious than most that are designed for amateur constructors, it is intended here to go to some length in detailing the features that have been incorporated. There is good reason for this. A circuit of this nature cannot be regarded simply as a multiplicity of stages strung together, as it were. The detail in one portion of the circuit affects that in other parts, for instance, and some features are necessitated by the inclusion of others. It is thus very important that intending constructors should have as complete an idea as possible of the reasons underlying many points in the design, so that the best practical use may be made of the theoretical diagram.

At the outset, it should be emphasised that this is not a set which any but an experienced constructor should undertake—especially on behalf of someone else. However, if the electrical and mechanical details are strictly adhered to, as set out herein, there is no reason why the excellent performance of the original should not be duplicated.

THE BLOCK DIAGRAM

Fig. 1 is a block diagram, showing the electrical layout of the receiver. It comprises two R.F. stages, oscillator-mixer, two I.F. stages, diode 2nd detector and noise limiter, two stages of audio amplification, separate A.V.C. amplifier and rectifier, a beat frequency oscillator, and a signal level or S-meter.

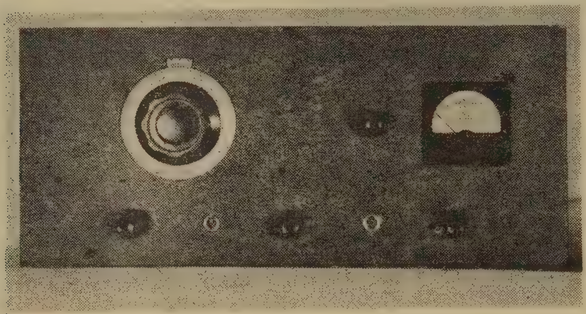
SIGNAL-TO-NOISE RATIO

In case this line-up should seem rather formidable in a receiver intended only for broadcast reception, it may be as well to give some idea of the manner in which we arrived at the final set up.

First and foremost came the question of signal-to-noise ratio. We do not intend to enlarge upon this point here, since a good deal has been written about it in our pages already, but, in view of its importance, two things decided themselves automatically; first, the infinite impedance mixer must be used, as it is the quietest mixer circuit that is easily applied at broadcast frequencies; secondly, an R.F. stage using the new double-triode cathode-coupled circuit must also be used, as it possesses better noise characteristics than even an 1852, and is much easier to operate successfully.

It is possible to argue that no R.F. stage is necessary at all if an infinite impedance mixer is used, but we did not subscribe to this view, mainly on account of the possibility of excessive image response. Thus, if an R.F. stage were to be used at all, it must be one which would not degrade the

high signal-to-noise ratio provided by the infinite impedance mixer. This, then is the reason for the 6SN7 R.F. stage. Any tube, triode or otherwise, is noisier when used as a mixer than when used as a straight amplifier, so that the triode R.F. stage can be expected to have a slightly better noise characteristic than the mixer stage.

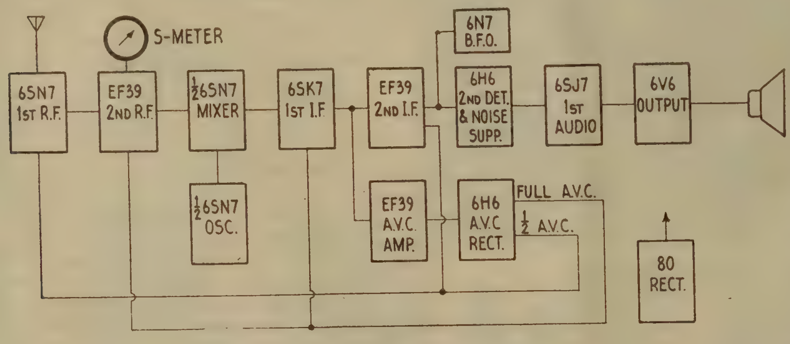


Front panel view of Broadcast 12.

TWO I.F. STAGES

So far, we have provided a high signal-to-noise ratio and enough image rejection for normal purposes. However, the mixer chosen has somewhat less gain than the ordinary multi-grid types, and the triode R.F. stage in turn has less than that of the average pentode R.F. stage. These deficiencies in over-all gain must be made up, and a little more, to allow for contingencies, so that two I.F. stages seem to be indicated.

These are capable of more than making up for the gain that has been lost, and in addition give the receiver a high order of selectivity—a very desirable feature in a set designed for DX reception.



AUTOMATIC VOLUME CONTROL

The next important point for consideration is that of A.V.C. In a receiver of this type the A.V.C. action must be much better than average, and must "hold" signals from an appreciable fraction of a volt down to a few microvolts. It is even more important in a broadcast set than in a short wave receiver, because on the broadcast band very deep fades often occur, unaccompanied by distortion due to selective fading. These deep undistorted fades can be virtually eliminated if only the A.V.C. characteristic of the set is good enough.

However much is gained by the use of the infinite impedance mixer, it cannot be denied that, especially on broadcast, the impossibility of applying A.V.C. to it constitutes a possible disadvantage. In addition, the use of the cathode-coupled R.F. amplifier imposes a further limitation, in that on the broadcast band it is unsafe to apply the full available A.V.C. voltage to it. Were this done, there would be a strong possibility of serious distortion on strong local signals; since even a special receiver like this one would presumably often be used for local listening as well as for DX-ing, this distortion must be kept to a minimum, so that full A.V.C. voltage on the 6SN7 R.F. stage is ruled out.

If, then, we have two I.F. stages, both of which can be controlled, and only one R.F. stage partially controlled, it seems unlikely that outstanding A.V.C. performance would be obtained.

TWO R.F. STAGES

Here, then, is the real reason for the inclusion of two R.F. stages. It is essential that there be adequate control in front of the mixer, in order to prevent all possibility of its being overloaded on strong signals, and to that end the EF39 2nd R.F. stage has been incorporated. It is not generally known that the EF39 has very good noise characteristics. In this respect, though not so good as the EF38, it is greatly superior to other types such as 6K7 or 6SK7, which might have been used in this position. Many will no doubt wonder why the EF38 has not been used in the 2nd R.F. stage, and the reason, unfortunately, is one of non-availability. There are virtually no stocks of this type in the country, and there seems little prospect of their arriving. However, in view of the low noise-resistance of the EF39 and the fact that it is preceded by the 6SN7 stage, the lack of an EF38 is very unlikely to cause any deterioration in performance.

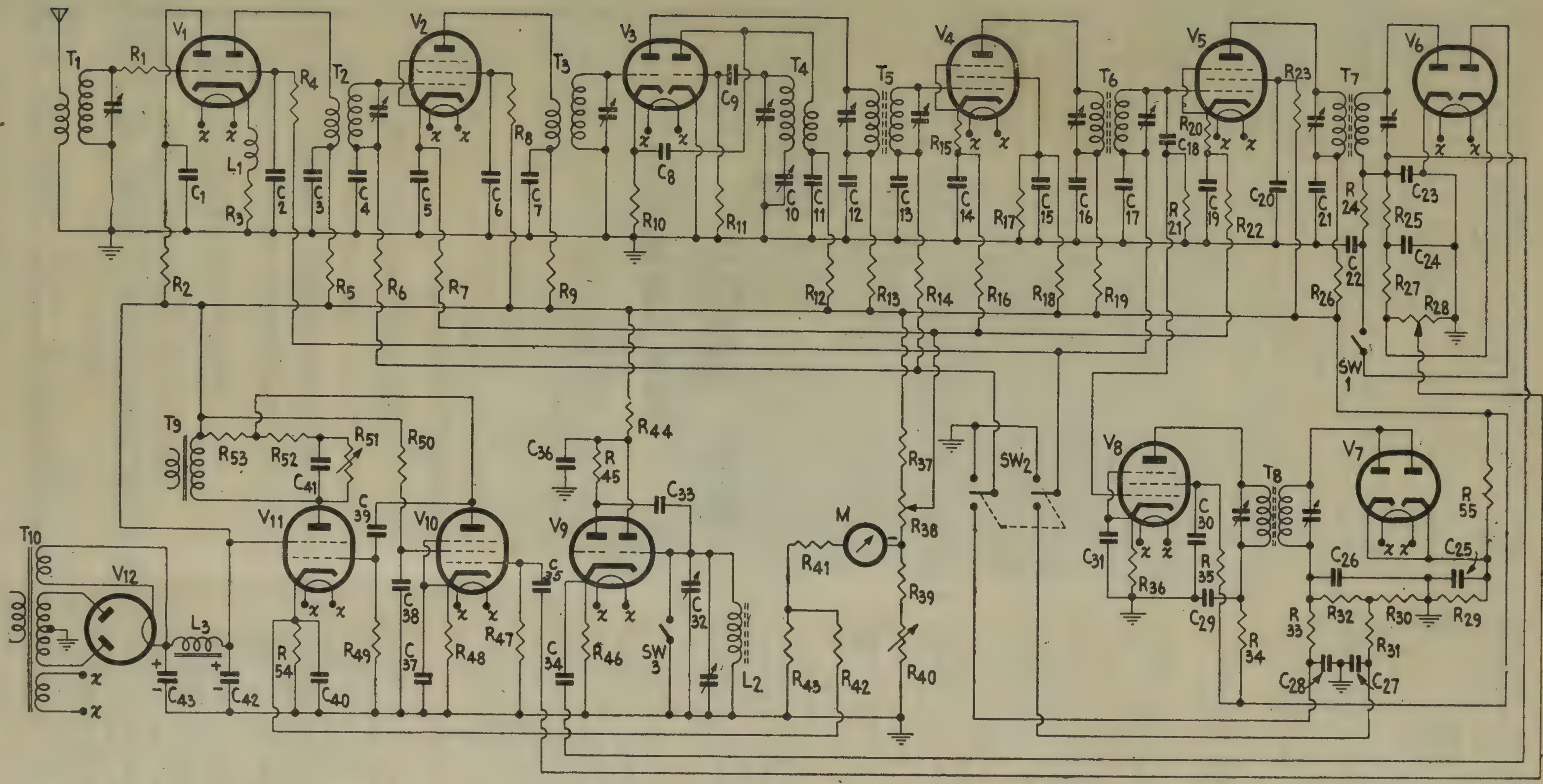
AMPLIFIED A.V.C.

Since it has been decided that a much better than average A.V.C. characteristic is desirable, the question of whether or not to use amplified A.V.C. crops up. In the first place, this feature does allow a very flat characteristic to be obtained. In addition, it eliminates a type of distortion which occurs in the second detector if an attempt is made to secure a good A.V.C. curve by using a high delay voltage on the A.V.C. rectifier. Further, it enables a better layout of parts to be used in the vicinity of the 2nd detector and 2nd I.F. stage. This is most important in a high-gain receiver like this one where, if a more usual 2nd detector-A.V.C. circuit is used, compact wiring is difficult to realise, and there is an increased possibility of I.F. instability —a thing to be avoided at all costs. As against these advantages, complete separation of the A.V.C. circuit from the 2nd detector circuit necessitates two extra valves, one for the A.V.C. amplifier, and the other as a separate A.V.C. rectifier.

Since, in this case, the emphasis is on performance, and ease of obtaining it, it was considered that amplified A.V.C. must be included.

TWO A.V.C. LINES

On the block diagram are shown two A.V.C. lines. To one of these are connected the 1st R.F. and 2nd



Resistances: R_1, R_{16}, R_{22} = 1500 ohms; R_2, R_5, R_9, R_{13}, R_{19}, R_{26}, R_{34} = 2000 ohms; R_3, R_7, R_{48}, R_{54} = 500 ohms; R_4, R_{11}, R_{14}, R_{17}, R_{25}, R_{30}, R_{32}, R_{44}, R_{45}, R_{37} = 50k.; R_6, R_8, R_{10}, R_{23}, R_{27}, R_{35}, R_{53} = 100k.; R_{12}, R_{18} = 25k.; R_{15}, R_{20} = 150 ohms; R_{21}, R_{49}, R_{50}, R_{52} = 500k.; R_{24}, R_{33}, R_{47} = 1 meg.; R_{28} = 1 meg. potentiometer; R_{29} = 10k.; R_{31}, R_{55} = 250k.; R_{36} = 4000 ohms; R_{39}, R_{43} = 200 ohms; R_{40} = 100-ohm potentiometer; R_{41} = 3000 ohms; R_{42} = 350 ohms; R_{46} = 5000 ohms; R_{38} = 10k. potentiometer; R_{51} = 2 meg. potentiometer.

Condensers: C_1, C_4, C_{17}, C_{25} = .02 mfd.; C_3, C_5, C_6, C_7, C_{11}, C_{12}, C_{36} = .05 mfd.; C_2, C_{13}, C_{14}, C_{16}, C_{19}, C_{20}, C_{21}, C_{22}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{35}, C_{38}, C_{39} = .1 mfd.; C_8, C_{23}, C_{24}, C_{26} = .0001 mfd.; C_9, C_{33} = .00001 mfd.; C_{15} = .005 mfd.; C_{18} = .00005 mfd.; C_{32} = 2-10 mmfd. variable; C_{41} = .001 mfd.; C_{37}, C_{40} = 25mfd. 25v. electrolytic; C_{42}, C_{43} = dual 8 mfd. electrolytic; C_{34} = two pieces of push back wire twisted together for ½ inch.

Valves: V_1, V_3, V_9 = 6SN7GT; V_2, V_5, V_8 = EF39; V_4 = 6SK7; V_6, V_7 = 6H6; V_{10} = 6SJ7; V_{11} = 6V6; V_{12} = 80.

Switches: SW_1 = toggle switch S.P.S.T.; SW_2 = toggle switch D.P.D.T.

Meters: M = 0-1 m.a.

Transformers: T_5, T_6, T_7, T_8 = 465 kc. I.F.'s; T_9 = speaker transformer; T_{10} = power transformer, 385-0-385v.—6.3v.—5v.; L_2 = B.F.O. coil.

I.F. stages, while the second line feeds the 2nd R.F. and 1st I.F. stages. The reason for this connection has been partly outlined already, viz., the 1st R.F. stage must have only a portion of the total available A.V.C. voltage applied to it. It is good practice, especially in multi-stage receivers, to apply only a portion to the last I.F. stage as well, as doing so improves the performance on strong signals, minimising modulation rise. Thus, the full A.V.C. voltage appears on the line feeding the 2nd R.F. and 1st I.F. stages, and one-half of the total comes from the second A.V.C. line to the other two controlled tubes.

THE AUDIO AMPLIFIER AND NOISE LIMITER

These two parts of the circuit may well be discussed together. First, the output stage is a 6V6, which will give a good 4½ watts output with low distortion, owing to the negative feedback used. The first audio stage is a 6SJ7, which allows plenty of audio gain to be realised in spite of the heavy feedback. The whole audio section will probably be recognised as the circuit used in the "Compact 4½-watt Gramophone Amplifier," which appeared in these pages some time ago. The tone control is noteworthy in that it does not cut off the higher audio frequencies, but actually boosts the bass and lower middle frequencies. With this receiver there is no necessity, nor is it advisable, to use the normal top-cutting type of control. For one thing, the selectivity of the I.F. amplifier is such that the highest audio frequencies are quite strongly attenuated in any case. Besides, the combination of the parallel-diode noise limiter with the bass-boosting tone control is a very valuable one, and is very effective in improving the readability of signals that are afflicted with a general hissing background of QRM.

The noise-limiter circuit is a new one, culled from a recent American communications receiver, and is very effective. Its action will be described in detail later, but is such that all noise impulses which are of greater amplitude than that of the carrier cause the input to the audio amplifier to be short-circuited momentarily, so that they are not heard in the output. Unlike most such circuits, this one does not need a variable control for most efficient working, all that is necessary being an on/off switch.

THE S-METER

In deciding to incorporate a meter for tuning indication rather than the more usual "magic eye" tube, a little has been added to the expense of the receiver, but in view of the somewhat *de luxe* nature of the job as a whole, this was not considered to be a grave disadvantage. The meter gives a much better tuning indication than the "magic eye," which is advantageous in a set like this which has an outstandingly good A.V.C. performance. A 0–1 ma. meter is employed, and the circuit is so proportioned that a scale reading of about 0.8 is obtained with the strongest local signal. In addition, the smallest signal likely to be usable gives a noticeable deflection. A special circuit is employed which renders the meter forward-reading in the usual manner, and which prevents overloads being applied when the manual R.F. gain control is used, and when the A.V.C. is switched off.

BEAT-FREQUENCY OSCILLATOR

While this is a somewhat unusual feature to find in a broadcast receiver, it is very helpful, not to say essential, in this one. Since the set-noise has been reduced to such a low level, weak carriers are difficult to detect, especially if the station is standing by, with no modulation applied. The B.F.O. enables such carriers to be detected quite easily and, after tuning in, can be switched off. It is also useful for finding carriers that are obscured by external noise, for the usual hiss which comes up on tuning across a carrier is almost eliminated in the receiver, owing to its low noise level.

Sufficient data has been given in the circuit and chassis diagrams to enable the intending builder to have his chassis made, and to start collecting the necessary parts. However, it is emphasised that the exact layout of the wiring is very important, as are the under-chassis baffle shields. For this reason, it would be inadvisable to commence wiring up the set until after the next instalment when we will have an opportunity to discuss exactly how the original model was wired up. In our next issue we will go on to describe the circuit and construction in detail, and readers are strongly advised to delay actual construction until the complete story has been unfolded.

(To be continued.)

RELEASE OF SURPLUS RADIO EQUIPMENT

(Advertisement of the War Assets Realisation Board.)

Several types of complete transmitter-receiver sets will be made available by the War Assets Realisation Board for direct sale to the public in the near future. Brief specifications of the various types are printed here as a guide to would-be purchasers. The price of each type will be announced when the Board advertises in the daily Press that the equipment is actually ready for sale. This is merely advance information, and the Board wishes to advise intending purchasers that no orders will be entertained or accepted until after the announcement referred to has been made.

In the following data, only main features have been included. In most cases there is a considerable amount of auxiliary equipment to go with each set, all of which are slightly used, and most, but not all, sets are complete with these extras. The following table shows the official titles of the various sets, together with the approximate number which are to be disposed of:—

Wireless Set No. 1	30
Wireless Set No. 108	300
Wireless Set No. FS6	200
Wireless Set No. 101	190
SCR131	100
Wireless Set No. 208	150

Individual descriptions of these sets follow.

Wireless Set No. 108—Mark II

This is a low-power transmitter-receiver for phone only, covering the frequency range 6 to 9 mc/sec. Power is from 1.5v. "A" and 90v. "B" dry batteries contained in a separate box. The transmitter-receiver itself weights 26¾ lb., and is 9½ in. x 9½ in. x 11¾ in. Current consumption is as follows: On "Send," 17 ma. "B" and 300 ma. "A." On "Receive," 6.5 m.a. "B" and 300 ma. "A." The unmodulated power input to the P.A. stage of the transmitter is approximately 0.5 watt. A 6 ft. telescopic whip aerial is provided with each set but a normal horizontal end-fed aerial may be used if desired.

Arrangements are made for pre-setting four frequencies simultaneously, any of which may be selected simultaneously, or for continuous tuning over the band.

The transmitter comprises two 1Q5-GT's in an M.O.P.A. circuit, the P.A. being plate-modulated by the output stage of the receiver when the send/receive switch is on "Send."

The receiver is a superheterodyne with an I.F. of 1600 kc/sec., and comprises 1P5GT or 1N5GT, R.F. amp.; 1A7GT osc. mixer; 1P5 or 1N5GT, 1st I.F. amp.; ditto, 2nd I.F. amp.; 1D8GT, diode 2nd det. 1st audio and output stage.

Wireless Set No. 101

This set is designed for C.W. and phone transmission and reception over a wave-band of 4.28-6.66 mc/sec. Power supply is from a 6-volt 25-amperehour battery, through a vibrator H.T. supply unit.

The complete equipment comprises transmitter-receiver unit, 38 lb. in weight, 21¼ in. x 12 in. x 8 in. in size, and vibrator unit, 24 lb. in weight, 16⅜ in x 10 in. x 4⅛ in. in size.

The transmitter is an M.O.P.A. using a 1K5G M.O. and two 1K5G's in parallel as P.A. Grid Modulation of the P.A. stage is used.

The receiver is a five-valve superhet., comprising 1C7G osc. mixer; 1K5G 1st I.F. stage, 1K7G, reflexed I.F. amp., 2nd Det., A.F. amp., and A.V.C. rectifier; 1C7G, B.F.O.; and 1K7G audio output stage.

The transmitter draws 17 ma. from the 210v. power supply, key down on C.W., and somewhat less on phone under no modulation conditions. Bias for all valves is obtained from the vibrator unit.

Wireless Set No. 208

This is a low-power C.W. transmitter-receiver covering the band 2.5–3.5 mc/sec. The transmitter section comprises a 1Q5GT Master Oscillator and 1Q5GT power amplifier. A built-in meter reads the P.A. plate current. The receiver has the following tube complement: 1P5GT, R.F. amp.; 1A7GT, Osc.-Mixer; 1P5GT, I.F. amp.; 1D8GT, 2nd Det. B.F.O. and Audio Amp. The set is designed to work with a Marconi aerial up to 70 feet in length, and the aerial coupling arrangements allow efficient transmitter loading into an aerial of this type.

The complete set consists of two units and a bag of accessories. The transmitter-receiver unit weighs 8¾ lb. and measures 9½ in. x 3½ in. x 5¼ in. Accessories include 70 feet of rubber-covered flex and a 12-foot star network counterpoise and insulators, etc., for the aerial, not included.

Battery consumption is as follows: "A" battery drain, 200 ma. on "Send" and 250 ma. on "Receive." "B" battery drain, 18 ma. on "Send" (key down) and 8.5 ma. on "Receive."

Wireless Set FS6

This set is a transmitter-receiver covering 4.2 to 6.8 mc/sec. for either C.W. or phone. It is operated from a 6-volt battery which provides H.T. supply via a vibrator unit. The battery drain is 3.2 amps. on "Receive" and 6 amps. on C.W., with key down. The main units are: Transmitter-receiver, 41 lb., 21¼ in. x 12 in. x 8½ in.; vibrator unit, 28 lb., 16⅜ in. x 10 in. x 4⅛ in.; battery box, 12 in. x 9 in. x 8 in.; remote control unit, 10½ lb., 9⅛ in. x 5¾ in. x 5¾ in.

The transmitter comprises a 1L5G osc.; 807 P.A. grid-modulated by a 1L5G modulator.

The receiver consists of 1C7G, osc.-mixer; 1K5G, 1st I.F. amp.; 1K7G, reflex I.F. amp., audio amp., 2nd det. and A.V.C. rectifier; 1K7G audio output stage, and 1C7G B.F.O.

Power input to the P.A. stage is approximately 7½ watts on phone and 15 watts on C.W.

Wireless Set No. 1

This is a transmitter-receiver for C.W. and phone use, operated from a 6v. accumulator for "A" and dry batteries for "B" supply. Frequency range is 4.28-6.66 mc/sec. The transmitter-receiver unit weighs 45 lb. and is 19¾ in. x 12 in. x 8⅛ in., and there are numerous accessories, including spare valves, aerial equipment, remote control unit, and remote aerial coupling unit.

The transmitter is an M.O.P.A. using two AR4-type valves. On phone the P.A. stage is grid-modulated directly by the carbon microphone input transformer.

The receiver is a T.R.F. regenerative using one stage of R.F. amplification autodyne detector, and

(Continued on page 47.)

FREQUENCY MEASUREMENT

PART VIII

Last month's instalment in this series described how the 2.5–7.5 mc/sec. range of a short wave receiver could be calibrated by means of the standard containing the 1000 and 100 kc/sec. series of signals. We go on now to describe the calibration of the next highest frequency range, which we will assume to cover 7 to 20 mc/sec.

The procedure for this band is quite similar to that used for the low frequency band. First of all, the multivibrator is turned off, leaving the 1000 kc/sec. series only. The signals from the standard are tuned in successively, and the pointer position for each carefully marked. The identification process is now recommended. In this case, the 10 mc/sec. point may be very readily found by tuning in WWV on this frequency. Note that the order of events should on no account be reversed, because in some receivers whose image response is not very good, two points will be obtained, one of which is the "real" signal and the other, the image. If this happens, the stronger of the two signals will be the required point, but if image response is very poor, this test may fail, since the two signals may be of comparable strength. If, in addition, the receiver is wrongly aligned, the image may even be stronger than the desired response.

IDENTIFICATION OF IMAGES

Needless to say, if image response is troublesome, each signal from the standard will have its own image, and twice as many signals as there should be will appear on the dial. The initial problem here is to identify the "real" signals, so that the images may be disregarded.

To illustrate the position which arises in a receiver using a 465 kc/sec. I.F., with the oscillator working higher in frequency than the signal, the received signals will be as follows:—There will be one on the true 10 mc/sec. point. Then there will be the image response of this at 9.07 mc/sec. Next will come the true signal at 9 mc/sec., the image response of this on 8.07 mc/sec., and so on. Thus, the spacing of the two series of signals will be such that a real signal and an image response will be found close together, separated by almost 1000 kc/sec. from the next signal with another image response close to it.

By this reasoning, the real 10 mc/sec. signal will have next to it the image response of 11 mc/sec., viz., 10.07 mc/sec.

This spacing of image responses and signals relative to each other enables the two to be distinguished quite easily, since, of each pair, the low frequency one will be real, and the other is an image response. It is as well, therefore, to mark tentatively both real and image response signals, and then to rub out the high frequency mark of each pair.

The case that has been described is the worst possible one, where the image response is as bad as it could well be, but even a receiver whose image rejection is good on the lower frequencies may have quite poor image performance on the highest frequencies of its range, so that it is well to be prepared for the worst in this respect.

A useful tip is that by reducing the coupling between the standard and the receiver, the image response is weakened more than the signal proper, so that in many cases identification of the images is rendered easier. Still, it should be stressed that the only real test is the method outlined above. This is important in case the R.F. circuits in the receiver have been accidentally aligned to the image frequency. Should this be the case, the real signal will be weaker than the image, and loosening the signal coupling will not improve matters. If it is suspected that the alignment is out in this way, the signal from the standard can be used as a check: if the high frequency signal of the pair is stronger, the R.F. alignment is wrong, and can be rectified by tuning the set to the real signal as identified by the test, and then re-trimming the R.F. circuits. Obviously, the oscillator trimmer should be left severely alone.

Note further, that although this scheme is correct for a 465 kc/sec. I.F. where the oscillator is supposed to work on the high frequency side of the signal, the situation is reversed should the oscillator be designed to work on the low frequency side, the usual case. In this event, the image response will be the low frequency one of the pair.

The identification scheme outlined above works well for a 465 kc/sec. I.F., but will not necessarily do so for other intermediate frequencies. If the I.F. is 456 kc/sec., the signals and images will still appear in pairs, but the spacing will be different. The image response this time will be $2 \times 456 = 912$ kc/sec. lower in frequency than its real signal (assuming high side oscillator working), so that the closely spaced signals will be at 9.088 and 9 mc/sec., 10.088 and 10 mc/sec., and so on.

As a further example, take the case of a converter, using an I.F. of 1500 kc/sec. Here, the image response should not be very bad, owing to the high I.F., but should it occur, the situation will be as follows:—The image response of 10 mc/sec. will be 10 mc/sec. $- 2 \times 1.5$ mc/sec. $= 7$ mc/sec. Similarly, the image response of 11 mc/sec. will be 8 mc/sec., and so on. Here it will be noticed that the image response will, in theory at least, be right on one of the other standard frequencies.

Thus, if the receiver is tuned to 8 mc/sec., the image response of 11 mc/sec. will be received at the same time. Since the real and image response signals are harmonics of the same oscillator, they will be at zero beat and it will be impossible to tell that an image is being received. As a result, the poor image response of the receiver will in no way confuse the issue! This happy state of affairs will occur if the I.F. is a multiple of 500 kc/sec., but in no other circumstances.

Another case worth mentioning is the one where the I.F. is an odd multiple of 250 kc/sec., i.e., 250, 750, 1250, 1750, etc. In each of these cases the images come exactly half way between one megacycle division and the next, so that it is impossible to tell by inspection which is an image and which is not.

It can be seen, therefore, that the inspection method of identifying images does not work in all cases, but that for intermediate frequencies in the neighbourhood of 465 kc/sec. it works well; also, for many of the likely higher I.F.'s the images will land on the megacycle points and can cause no trouble.

USE OF AN AUXILIARY OSCILLATOR

Should the I.F. be such that images cannot be identified with certainty merely by inspection, the auxiliary oscillator with a fairly rough frequency calibration can again be used to find a way out of the difficulty. This method is not suitable on the occasions when the inspection method works best, and so is complementary to it. An example will again be the easiest way of explaining the system to be used. Suppose, for example, that the I.F. is 1750 kc/sec. with the oscillator operating on the higher frequency side of the signal. Here, an image response of the 10 mc/sec. signal will appear when the receiver is tuned to what should be 6.5 mc/sec., the image response of 11 mc/sec. will be at the 7.5 mc/sec. mark, and so on. The real and image response signals will, therefore, be spaced every 500 kc/sec. across the dial, and the inspection method is impossible.

The first step is to mark all these points, real as well as image, with a pencil. The success of this method depends on the fact that for a certain distance up from the low frequency end of the receiver dial no images can be received from a single frequency source such as a simple oscillator. This is because an image, assuming high-side working of the local oscillator in the receiver, is always received at a lower frequency setting than its corresponding real signal. Thus, if the receiver is tuned to the low frequency end of the band, and the frequency of the auxiliary oscillator increased from some low value until the first signal is heard in the receiver, this signal must be a real one.

In the case we are using as an example, the lowest frequency on the band is somewhere near 10 mc/sec., and the I.F. is 1750 kc/sec. The receiver is, therefore, tuned to one of the signals from the standard that is nearest to the low frequency end of the scale. The standard is then uncoupled from the receiver and the auxiliary oscillator turned on and tuned to, say, 9 mc/sec., to be on the safe side. It is now loosely coupled to the receiver, and the dial turned slowly so as to increase the frequency. During this operation, the receiver remains untouched. At length, a point is reached where the signal from the oscillator crosses the frequency to which the receiver is tuned, and is heard. The oscillator is now tuned to exact resonance with the receiver, and its frequency is read off from its own calibration.

Suppose that the oscillator dial reads 10.5 mc/sec. In this case, it has been established that the receiver is tuned to its dial frequency of 10.5 mc/sec., which must, therefore, represent an image of one of the signals from the standard. The next lowest mark on the receiver dial must, therefore, be 10 mc/sec. This frequency can now be permanently inked in, as can alternate marks thereafter, these being 11, 12, 13, etc., mc/sec.

Note that the image points at 10.5, 11.5, etc., mc/sec. should **not** be used as calibration points, since they are not necessarily accurate, depending for their position on how accurately the receiver is aligned to its nominal I.F. of 1750 kc/sec. This is not the case with the megacycle points, however.

This process of identifying the images by means of an auxiliary oscillator serves simultaneously to fix one of the megacycle points so that the calibration can be completed by counting as with the low frequency range.

(To be continued.)

Permanent Magnet Speakers in A/C Receivers and Amplifiers

For some considerable time there have been on the market receivers whose speakers employ a permanent magnet instead of the more usual field coil energised from the H.T. supply. This practice is becoming general among manufacturers; it has much to recommend it, and will in the future be commonplace.

For many years it has been customary to look upon the permanent magnet moving-coil loud-speaker as something to be used in the small sizes, only for battery-operated receivers and amplifiers, and in the larger sizes, for public address amplifiers and other applications where the field-coil leads would constitute an embarrassment. The field coil itself has been regarded as a necessary and cost-saving device on account of its ability to replace a choke in the H.T. smoothing filter circuit.

There are, however, several advantages to be gained by reversing the *status quo,* and employing permanent magnet speakers in small sets and amplifiers. Perhaps the most notable is that with modern manufacturing methods it is actually cheaper to produce a permanent magnet speaker and a separate smoothing choke as against an electromagnetic speaker. It should, therefore, reduce a manufacturer's costs were he to depart from the standard practice of the E.M. speaker.

Further reductions in the manufacturing costs occur when a P.M. speaker is used. In the first place, the power transformer no longer has to supply the watts necessary to energise the field coil. This power varies between 5 and 10 watts in the case of the average receiver. Although this is negligible as far as mains consumption is concerned, such power represents a substantial percentage of the total drawn from the transformer secondaries, so that a corresponding saving is effected in the design of the transformer. Again, it is the necessarily high voltage drop in the average field coil that has resulted in the comparatively high secondary voltage of 385v.-a-side becoming almost standard throughout the industry. When a P.M. is used, the H.T. winding need not be more than 300v.-a-side at the most. This, in turn, brings a further economy, in that for small sets drawing no more than 70 ma. H.T. current, the 6X5 may be used as the rectifier. Since this tube has a 6.3-volt heater-cathode construction, and is designed to withstand the heater-cathode voltage developed if the heater is earthed, the power transformer may now have only one heater winding for the whole set, instead of a separate 5-volt rectifier filament winding in addition to the 6.3-volt winding.

SMOOTHING RESISTANCE POSSIBLE

In some cases, notably those of the smaller receivers, it is possible with perfectly satisfactory results to replace the smoothing choke by a resistor. There is an obvious compromise here between smoothing effect and voltage drop in the resistor. If the drop is too high, the transformer voltage must be increased again, thus losing two of the above-mentioned advantages. However, resistance-capacity smoothing is perfectly practical now that high-voltage electrolytic condensers of 40 mfd. and more are available, and is worthy of very serious consideration by the designer of small sets.

OTHER ADVANTAGES

So far, stress has been laid on the fact that a P.M. speaker can materially reduce the set-manufacturer's production costs, but there are improvements in performance to be taken into account, too. The absence of a field winding on the loud-speaker actually reduces the acoustic hum output, for in acting as the sole smoothing choke, the field coil invariably causes a certain residual hum to be heard, which can be reduced only by increasing the input filter condenser to dangerously high values. A 6X5, however, may be used with a filter whose input condenser is not larger than 40 mfd., so that single stage CR or CL filter can be made to yield a D.C. supply so smooth that the loud-speaker hum is virtually zero.

It is well known, too, that permanent magnet speakers give a certain clarity and "sparkle" to reproduction, which is noticeably lacking in many small E.M. speakers.

An advantage of the P.M. speaker which is often overlooked is the fact that it enables a higher power output to be obtained from a given output tube. This is because the overload characteristic of an output stage using an E.M. speaker is inferior, especially when the tube is a pentode. The reason is that when slight signal overloads are applied to the output valve, the latter departs from class A operation, and the plate current either dips or rises somewhat. In passing through the field winding, this current variation changes the field excitation (and therefore the acoustic sensitivity of the speaker) resulting in an increased flattening of the curve of output versus input voltage. This means that the point of objectionable overload is reached sooner and more suddenly sharply than if a P.M. speaker were used. Thus, a P.M. speaker allows a somewhat greater power to be obtained from the output stage.

SUMMARY

The advantages of the P.M. speaker are thus seen to be considerable, and may be summed up as follows:—

(1) A P.M. speaker and separate choke costs less to manufacture than an E.M. speaker of corresponding size.
(2) Reduced power and H.T. winding voltage are required from the power transformer, further reducing costs.
(3) Where the 6X5 rectifier can be used (owing to the lower H.T. winding voltage) the power transformer can be further cheapened by the omission of the separate rectifier filament winding.
(4) Lower residual hum from the loud-speaker.
(5) Better reproduction.
(6) Better overload characteristic in the power amplifier stage through elimination of the field-choke arrangement.

DESIGN OF BATTERY OPERATED RECEIVERS

Any or all of several factors can influence the life of the "B" batteries used to operate portable receivers. Since these factors are all under the control of the set designer, this article has been prepared from data kindly made available to us by the National Carbon Co. Pty. Ltd., and should prove of great value to designers, both from the standpoint of achieving optimum results from the receiver itself, and in enabling the greatest use to be made of a set of batteries before replacement is necessary.

FACTORS INFLUENCING "B" BATTERY LIFE

The "A" battery end-point voltage in 1.4 volt receivers is largely a function of tube design and is practically independent of the radio receiver circuit. This is not true in the determination of "B" battery end-point voltage, or the voltage below which the "B" batteries are no longer usable.

The "B" voltage end-point is determined by one or more of four factors. These are:

(1) Radio frequency sensitivity.
(2) Oscillator cut-off.
(3) Maximum power output.
(4) Distortion in audio output.

Any one of the above factors can influence "B" battery life profoundly, and the well-designed 1.4-volt receiver is one in which all of these factors are kept in balance over the usable range of "B" voltage.

RADIO FREQUENCY SENSITIVITY

After testing more than one hundred 1.4-volt receivers of all types having loop antennas, and as a result of careful study of average field strength conditions, the National Carbon Company Research Laboratories have selected what they consider to be a representative end-point condition in terms of signal strength and receiver sensitivity. This condition is defined as that receiver sensitivity which, with a field strength at 1000 kc/sec. of 1250 micro-volts per meter, modulated 30 per cent. at 400 cycles, will yield a 10-milliwatt audio output. The lowest "B" battery voltage at which the performance of the receiver fulfils this condition is considered the end-point.

Fig. 1 illustrates typical performance curves for two 1.4-volt portable receivers. Receiver A typifies a well-designed receiver. Receiver B is representative of a receiver that penalises the user from an operating cost standpoint. It is evident from this curve sheet that in the case of receiver A, inadequate power output would determine the useful "B" battery life, while poor R.F. sensitivity would determine the "B" voltage end-point for receiver B. It is evident that the "B" batteries in receiver A could be used down to an end-point of 12 volts per 22½-volt section, while the "B" voltage end-point for receiver B would be 17 volts per 22½-volt section. The user is thus deprived of the energy available from the "B" batteries between 17 and 12 volts per 22½-volt section, in the case of receiver B.

LOOP ANTENNA DESIGN

One of the most important considerations for the maintenance of sensitivity in portable receivers is the design of the loop antenna. The figure-of-merit for any tuned loop antenna can be shown to be the product of the "Q" for the loop, the mean loop area in square meters, and the number of turns, or Q.A.N. In evaluating the importance of loop design, the laboratory investigated nine different portable receivers, all having essentially the same I.F. and A.F. circuits, but with various types of loops. Q.A.N. values for the nine receiver loops varied from 81.5 to 17.1.

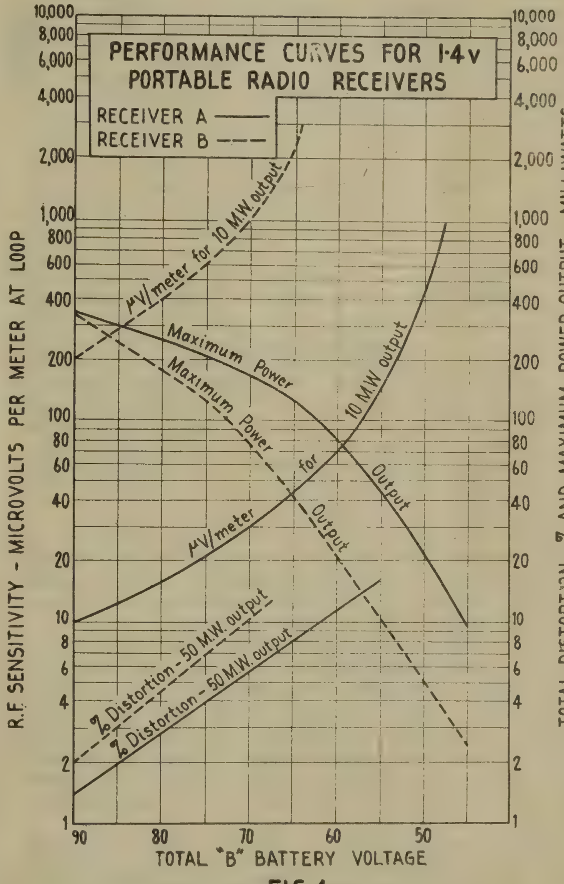


FIG. 1

It is evident from this that there was an almost 5 to 1 variation between the highest and lowest loop values, and tests showed that the receiver with the highest Q.A.N. figure had excellent maintenance of sensitivity, while the receiver with the lowest figure was inferior in this respect. In short, the selection and location of a portable receiver loop antenna can by itself result in excellent or inferior "B" battery life for the same receiver.

OSCILLATOR CUT-OFF

The design of the oscillator circuit in battery-operated super-heterodyne receivers also affects the "B" battery end-point voltage. It is important that the oscillator continue to function at a "B" voltage below that at which one of the other three factors mentioned above causes the "B" batteries to be no longer useful. The oscillator circuit will do this in most 1.4-volt battery sets. It is important to select a series voltage dropping resistor for the screen grid of the first detector-oscillator tube of such value that the rated screen voltage for the tube is not exceeded. A screen voltage at this point in excess of the rated value will cause an appreciable increase in the total "B" current drawn by the receiver and a corresponding decrease in "B" battery life.

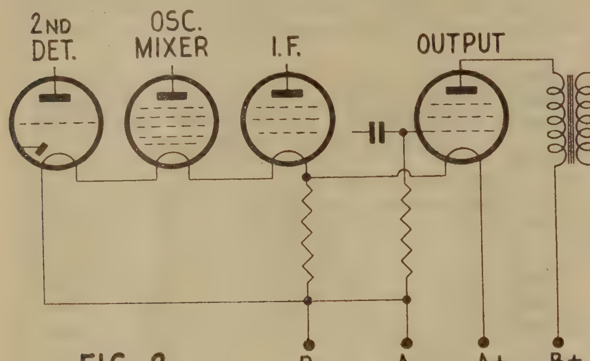


FIG. 2

POWER OUTPUT

As indicated by Fig. 1. a receiver may have adequate R.F. sensitivity at low "B" voltage and still not be satisfactory in operation because the audio power output is inadequate. This is more generally true of receivers with series filament operation than of receivers with parallel filament operation. This point is illustrated in Figs. 2 and 3.

Fig. 2 illustrates a 1.4-volt receiver in which the tube filaments are connected in series for battery operation. The output tube filament is positive with respect to ground by an amount equal to the voltage drop across the other three filaments.

This means that the control grid is negative with respect to the filament by the same amount, and, accordingly, the output tube grid bias is proportional to the "A" battery voltage. If the battery complement is so worked out that the "A" battery voltage does not drop as rapidly as the "B" battery voltage, the output tube will be over-biased at low "B" voltage and an adequate power output cannot be maintained.

On the other hand, if the "A" battery voltage drops more rapidly than the "B" voltage, excessive plate and screen currents will flow in the output tube and the result is again short "B" battery life.

Fig. 3 illustrates a 1.4-volt receiver in which the tube filaments are operated in parallel for battery operation. In this case, a self-bias resistor is inserted in the negative "B" leads, and the output tube control grid is maintained at a voltage that is negative with respect to the filament by an amount proportional to the "B" voltage. By careful selection of the self-bias resistor value, optimum relation between plate voltage and grid-bias voltage can be maintained at low "B" voltages. Then maximum power output for low "B" voltage values will be realised.

Another method of obtaining bias voltage for the output tube in receivers having parallel connection of tube filaments has been used. Briefly, this method consists of connecting the output tube control grid, through a suitable filter network, to the oscillator grid in the oscillator-mixer tube. The apparent advantage in this circuit is that under ideal conditions the oscillator grid is maintained at a voltage sufficiently negative to bias the output tube, and thus self-bias is achieved while at the same time the full "B" battery voltage is impressed from plate to filament in the tubes in the receiver.

Using the oscillator tube as a source of bias voltage for the output tube has three principal disadvantages, however. First, the bias voltage becomes a function of oscillator frequency. Second, the bias voltage decreases as the "B" voltage decreases, which is desirable, but it might not decrease at the rate required to realise optimum conditions in the output stage for all values of "B" voltage over the usable range.

By giving careful consideration to the circuit elements involved, the two effects described can be minimised, but this statement is predicated on the assumption that tube characteristics will not depart from published values or curves. The third and most important disadvantage of the oscillator voltage-output bias circuit is that tube characteristics do vary from nominal values. This makes it virtually impossible to predict what conditions will prevail in receivers in that field.

The worst conditions that might prevail is the combination, in one receiver, of an oscillator tube with low mutual conductance and an output tube with high plate current. This combination results in excessive plate and screen currents in the output tube and reduced tube and "B" battery life. This effect can be minimised in production by careful selection of tube complements, but there is no means of control when oscillator or output tubes are replaced by the receiver user.

Battery-operated sets using the oscillator voltage-output bias circuit have come to the attention of the National Carbon Company in which the "B" battery drain was more than twice the rated value. Investigation showed that the excessive drain was due to the combination of tube characteristics as described above.

THE "ECONOMISER"

Fig. 4 suggests a method of further conserving "B" battery power. This is the "Economiser" circuit introduced by the National Carbon Company in 1937 for use in battery receivers then using 2.0-volt tubes. Economies up to 50 or 60 per cent. in "B" drains were thereby effected in these receivers. This circuit has since been used in numerous 1.4-volt receivers. The method consists of providing a self-bias resistor composed of two sections, one of which may be shorted by means of a switch "S." When the "B" batteries are new, switch "S" is opened, thus over-biasing the output tube and reducing the initial plate and screen currents of all the tubes in the receiver. As the "B" voltage is reduced with time, switch "S" is closed, reducing the resistance of the self-bias resistor, and thus providing greater power

output and less distortion than would be available at the same reduced "B" voltage with "S" open. The initial power output is somewhat reduced and distortion increased with this circuit, but not sufficiently to affect the output, from the listener's standpoint. The economiser circuit therefore gives the user the choice of maximum set performance with normal "B" current consumption or adequate performance at reduced "B" current drain with longer "B" battery life.

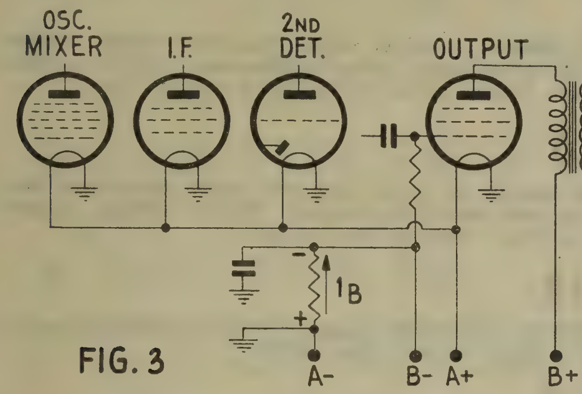


FIG. 3

DISTORTION IN AUDIO OUTPUT

Distortion of the audio output from a 1.4-volt receiver is sometimes a reason for discarding "B" batteries, but this factor is not nearly as frequently important as reduced R.F. sensitivity or adequate power output. Careful selection of the output tube biasing method and agreement of the actual output tube load impedance with the tube manufacturer's rating will minimise the distortion factor.

Importance of Low "B" Voltage Cut-off

Most of the preceding discussion is aimed at improvement in 1.4-volt battery receivers from the standpoint of usability at low "B" voltage. Years ago, the impression prevailed that the "B" batteries were completely discharged when they had reached a closed circuit voltage of 17 volts per 22½-volt section, and that nothing was to be gained by designing a receiver to give satisfactory operation at voltages below this value.

A curve plotted between hours' life and voltage of the early batteries would be falling rapidly in voltage at 17 volts and would give but little additional life beyond that point. Battery manufacturers, in their endeavour to increase the high voltage service from a "B" battery, have flattened the discharge curve in the region of 17 volts, so that the service obtainable to lower voltages is markedly increased.

In the case of typical 1.4-volt receivers equipped with "B" batteries representative of modern manufacturing methods, it is estimated that up to 50 per cent. increase in battery life can be realised by designing a receiver to operate down to a "B" voltage of 12 volts per 22½-volt section instead of to a 17-volt limit. The ampere hour capacity available at these lower voltages is doubly valuable because of the reduced battery drain in this region, which causes each ampere hour to last much longer than at the higher voltages.

Internal Resistance

As the "B" battery falls in voltage with service, the internal resistance rises. At voltages higher than about 18 volts per 22½-volt section, the magnitude of this resistance is ordinarily not great enough to give concern to the designer of the battery-operated receiver. However, in order to extend the satisfactory operation of the receiver to the lower voltage range, so as to exhaust the "B" battery fully as previously described, the possible effects of this resistance must be recognised in the design of the receiver. The chief source of this increased resistance in a dry cell is the accumulation of the waste products of the chemical reaction which accompanies the discharge. These gradually plug up the conducting paths within the cell and in consequence increase its resistance.

The actual magnitude of this resistance varies somewhat in accordance with the brand, previous history, and rate of discharge of batteries. Measurements have been taken on a large number of such batteries, including representative cases of the variables noted. A suitable method of measurement has been developed, which consists in reading with a vacuum tube voltmeter the alternating voltage drop produced across the battery terminals by the passage of a known alternating current through it. The conditions of measurement are representative of the actual behaviour of the battery in a radio circuit, and serve to evaluate directly the factors responsible for the regeneration phenomena about to be described. As the result of these measurements, a resistance value of 330 ohms per 22½-volt battery section has been obtained as representing the maximum to be normally expected in radio service to 12 volts per section. A tabulation of internal resistance values of "Farm" type and "B" batteries for the various "B" voltages used at test points in the research laboratories might be of interest. These are:

Volts/22.5v. Section.	Res./22.5v. Section.
24	0 ohms
22.5	0 ohms
20	10 ohms
17	50 ohms
15	110 ohms
12	250 ohms

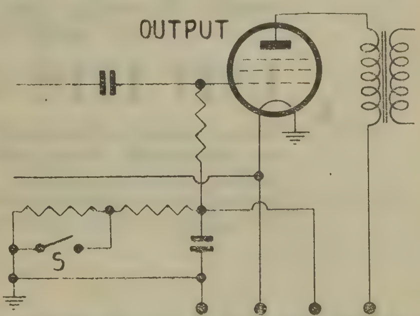


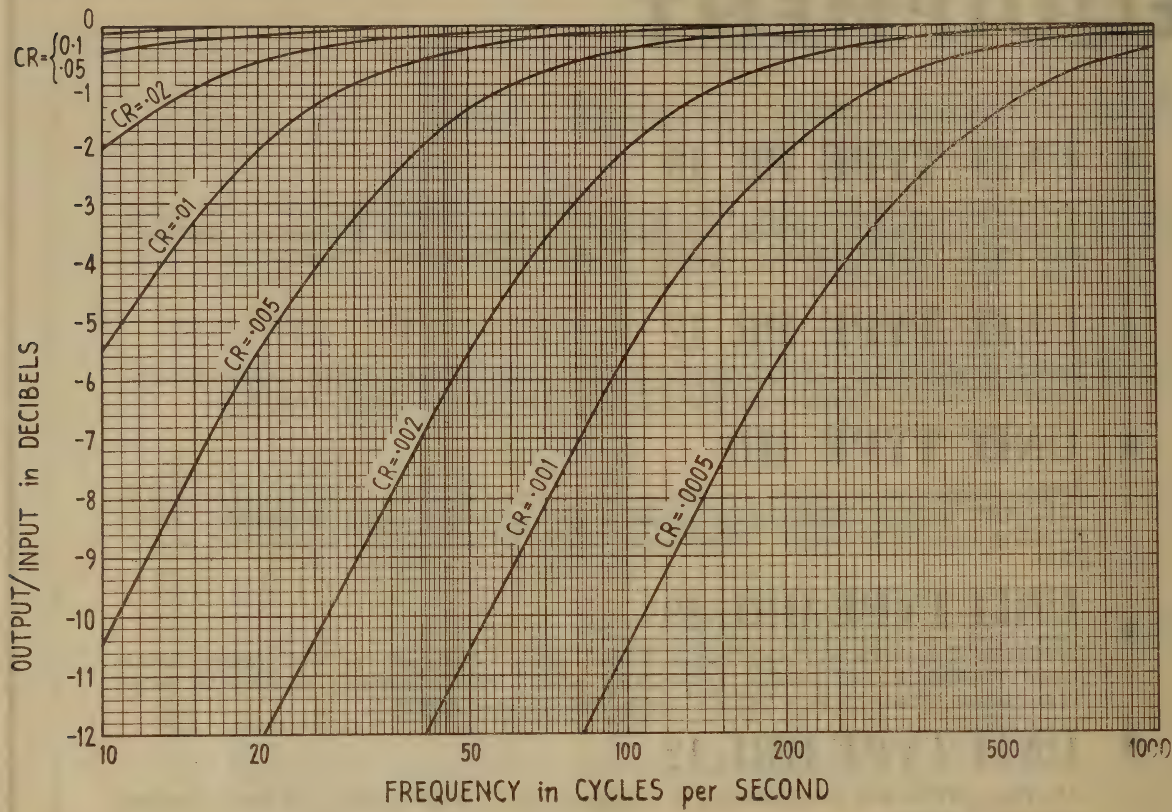
FIG. 4

The values applying to portable types of "B" batteries are as follows:—

Volts/22.5v. Section.	Res./22.5v. Section.
24	40 ohms
22.5	45 ohms
20	60 ohms
17	110 ohms
15	175 ohms
12	330 ohms

(*Continued on page 48*)

DESIGN SHEET №4 :- FREQUENCY RESPONSE OF CR CIRCUITS



THE FREQUENCY RESPONSE OF CR. CIRCUITS

When a coupling condenser-grid leak combination is used in any circuit carrying audio frequencies, as, for example, in Fig. 1, the relative size of the condenser C and the grid leak R determine the low frequency response of the whole circuit, other things being equal. In general, one knows that the low-frequency loss due to the imperfect by-passing of cathode bias resistors can be made negligible by using a 25 or 50-mfd. cathode by-pass condenser, and that the loss in the coupling network can be made small enough by having a large enough condenser at C. It is frequently useful, however, to know just how much low-frequency loss is caused by given values of C and R, especially where an audio amplifier is being designed to have a purposely attenuated bass characteristic.

The calculation of the frequency response curve of a particular combination of C and R, though not difficult, entails a great deal of tedious arithmetic, and if this has been completed and found not to give quite the required answer, it would need to be performed all over again. This design sheet, therefore, has been prepared to enable the low-frequency performance of individual couplings to be estimated at a glance. The curves each show the actual response of an unlimited number of CR combinations, since each curve has been labelled with the value of the product CR, which, for purposes of the chart, is worked out in megohms and microfarads.

HOW TO USE THE CHART

Suppose we wish to know the response curve at low frequencies of a combination where R = 1 meg. and C = .0005 mfd. Thus, CR = .0005, and the response curve will be that one on the chart which is labelled with this value.

If now we wish to know what improvement in low-frequency response may be effected by increasing the value of C to 0.01 mfd., leaving the grid leak at 1 megohm, we find mentally that CR = 0.01, which has its own curve on the sheet. Once the appropriate response curve has been located, the drop in response at any frequency from 10-1000 c/sec. may be read from the curve.

Suppose that it is desired to design a single stage, say, for a speech amplifier, in which the bass response below 100 c/sec. is to be attenuated as much as possible. The procedure is now as follows. Since a drop of 2 db. is barely discernible by ear, we need to find the curve for which there is a 2 db. drop at 100 c/sec. By inspection of the curves, the correct one is found to be the one for CR = .002. This gives a 6db. drop at 50 c/sec., and 10.4 db. drop at

(*Continued on page 47*)

A Practical Beginners' Course

PART IX

Last month, in discussing the flow of electric current through a conductor, and comparing it with the flow of water through a pipe, we finished with the important conclusion that the current flowing in a circuit depends, first, upon the electrical resistance of the circuit, and, secondly, upon the electrical pressure maintained by the battery or generator which is causing the current to flow. Now, we will go on to illustrate this point further, and to introduce some of the proper electrical terms we will need to know.

Just as when talking about length we must have units of length in order to make measurements, so when we deal with electrical resistance, we must have a unit of resistance in order to make electrical measurements. This unit of electrical resistance is called the **ohm,** after a scientist, Ohm, who discovered the important fact given in the first paragraph. If we wish to know how much current will flow in a wire under certain circumstances, we must know the numerical value in **ohms** of the wire's resistance, just as in measuring the length of an object we must know the numerical value of its length in **feet.** In our work with electric currents, we will find it necessary to use components which have a resistance of only a small fraction of an ohm, and others with resistances of many millions of ohms. For example, the coils we have constructed for our crystal sets have resistances of only a very small fraction of an ohm (a few thousandths), while the coils of fine wire to be found in the headphones we have used have a total resistance of about 2000 ohms.

VOLTS AND VOLTAGE

We have already mentioned the fact that the current flowing in a circuit depends on the electrical pressure of the battery or generator used to cause the flow of electrons. This pressure also has a unit by which it is measured, called the **volt** after Volta, an Italian scientist who made the first practical electric battery. It is beyond our scope here to try and explain how units such as the ohm and the volt came to be chosen, and why they are just so big, and so on, but it is necessary to give some idea of the electrical pressures or voltages commonly used.

For example, the ordinary dry cell used in torch batteries has a pressure of 1½ volts. It should be explained here that a **battery** strictly speaking is a **number** of cells connected together in some way. For example, the small flat batteries used in flat torches contain three cells, and have a voltage of 4½ volts, or three times the voltage of one cell. Of the torches which use the round cells, a two-cell torch has a voltage of 3 volts, while a three-cell one has 4½ volts. The flat cycle battery has 3 volts, since it consists of only two cells.

As a further illustration, the lighting mains used in our homes have a pressure of 230 volts, which is enough to give one a nasty shock, or even, in some cases, to cause death. The voltages employed in torch batteries are so small that it is impossible to feel a shock by taking hold of the terminals. Again, accumulators such as those used in car batteries and for other purposes where heavier currents are required than "dry" cells can provide, have a pressure of two volts per cell, so that the usual car battery consists either of three cells, making 6 volts in all, or of six cells, giving 12 volts.

CURRENT

Since we have electrical units for measuring resistance and electrical pressure, there must also be a unit with which to measure current. This is called the **ampere** after another early electrical worker. A current of 1 ampere (or amp. for short) is quite large, and represents a flow of many millions of electrons a second. As we stated above, the size of an electric current depends both on the resistance of the circuit and on the voltage of the battery or generator. The exact way in which this current is related to the voltage and resistance is very simple, and may be easily expressed by an example. **If a circuit has a resistance of 1 ohm, and it is connected to a battery giving a pressure of 1 volt, then the current flowing in the circuit is 1 ampere.** Also, if

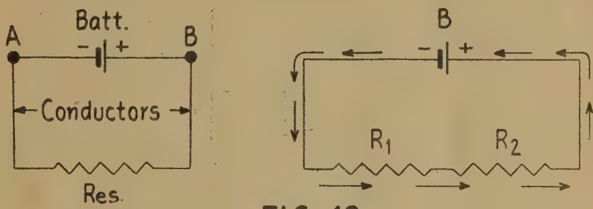


FIG. 10

the resistance or voltage (or both) are varied, then the current will vary in proportion. For instance, if a 2-volt battery is connected to a circuit of 1 ohm resistance, the current will be 2 amperes. Or, if a 1-volt battery is connected to a resistance of 2 ohms, the current will be ½ amp., and so on. Those of you who have done a little algebra will be interested to know that the formula connecting current, resistance and voltage is,

$$I = \frac{E}{R},$$

where I is the current in amps., E the pressure in volts, and R is the resistance in ohms. In radio work, currents are not often measured in amperes, because receiving valves seldom draw currents as large as this. The unit of current usually used is the **milliampere** or **milliamp.,** which is one-thousandth of an ampere. The proper abbreviation for milliamps is **ma.** Thus, if a circuit has a resistance of 1000 ohms, and is connected to a 6-volt battery, the

$$\text{current} \quad I = \frac{6}{1000}$$

or 0.006 amp. This is normally referred to as 6 ma.

RESISTORS

In dealing with electric currents flowing in more or less complicated circuits, it is very helpful to use the terms **series** and **parallel** which describe the manner in which the parts of a circuit may be joined together. In order to explain what is meant, we have here Figs. 10, 11, 12 and 13. These will form the basis of quite some discussion, since there are several things in them that are new to us.

The left-hand part of Fig. 10 shows a battery connected to a **resistor** (Res.) by means of wires or **conductors.** A and B are the terminals of the battery, which is represented by the symbol in

between. The symbol itself consists of a long thin line next to a short fat one. The former has been labelled + while the latter is labelled —. This is because in many cases it is important to the working of a circuit that the current should flow in some particular direction.

The battery terminal to which electrons flow from the outside circuit is called the **positive** terminal, and is always represented by the long thin line. In our case, we have put in the signs + and — only to emphasize this fact, but it is not really necessary to do this, as the symbol for the battery, once understood, indicates automatically which terminal is which.

So far, we have not explained the term **resistor,** or the symbol which illustrates it. All electrical conductors have some resistance, but the copper wires used to connect the parts of a circuit together are made in such a way that this resistance is exceedingly small—so small, in fact, that for most purposes their resistance can be disregarded altogether. Often, however, we wish to **control** the current which flows

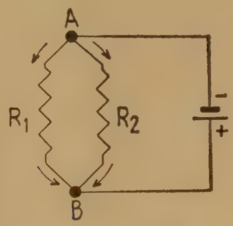


FIG. 11

in a circuit. That is, we may want it to be so many amps or milliamps, and no more. If this is the case, one way we could do the job would be to make the connecting wires of something which has a very high resistance. This scheme would work quite well, except for the fact that, if the resistance we require is more than a few ohms, very long connecting wires would have to be used, which would be very inconvenient. To get over this, we could wind the wire (adjusted to the resistance we want) in the shape of a coil on a small former an inch or two long and about half an inch in diameter. This device would give us the resistance we require, whilst taking up very little room. It could then be connected to the circuit in the most convenient manner by the usual copper wire.

This small coil, wound with special high resistance wire, is called a **resistor** which simply means a device where some electrical resistance is concentrated purposely into a small space.

Practical resistors are not always made of wire. Often some non-metallic substance is moulded into a short rod, and connecting wires of copper are attached to its ends. In fact, this type of resistor is always used where very high resistances are required because the composition material is made with a very much higher resistance than that of any metallic wire, and so is able to give us very high resistances in a small space—a thing which would be impossible if all resistors had to be made from wire. However, wire-wound resistors, as they are called, have their place in the scheme of things, and for some purposes must be used in preference to the composition or carbon type, as it is usually called.

Carbon resistors can be made in values of a few ohms to about 50 megohms, or 50 million ohms, and so are very versatile. Wire-wound resistors are rarely made in values higher than 100,000 ohms, but can also be made in smaller values than are usually found in the carbon type. Where heavy currents are flowing, wire-wound resistors must be used, because they are able to work hot without any detrimental effects, whereas carbon resistors, if run hot, do not keep to their marked value.

We can now complete our description of the left-hand circuit of Fig. 10. The zig-zag line is the symbol used to represent a resistor in circuit diagrams. The circuit diagram itself cannot tell us the size of the resistor, so that this must be indicated either by writing it next to the symbol, or by labelling it R_1 or R_2, and then printing a list under the circuit giving the value of all resistors in it.

SERIES AND PARALLEL CIRCUITS

Having digressed to explain what a resistor is and how it is indicated in a diagram, we can now return to the question of the terms **series** and **parallel.** The easiest way of doing this is to refer to the right-hand half of Fig. 10, and to Fig. 11. In both these diagrams we have a cell or battery connected to two resistors, R_1 and R_2, but the circuits are quite distinct and separate, in spite of the fact that the same three components are used in each. In Fig. 10, the electrons flow from the negative terminal of the battery, through R_1, then through R_2 and back again to the positive battery terminal. In Fig. 11, however, the electrons flow along the connecting wire to the point A. At this point some of them flow through R_1 and some through R_2 to B, after which they all flow back to the battery as before.

In Fig. 10, the resistors are said to be connected in **series,** while in Fig. 11 they are connected in parallel.

It is readily seen that in the first case the whole current flows first through R_1 and then through R_2. There is only one current in the circuit, and its size depends on the **sum** of the two resistances. Electrically, the result in Fig. 10 is the same as if R_1 and R_2 were replaced by a single resistor whose value is equal to the sum of the two separate values. For example, if R_1 is 10 ohms and R_2 is 30 ohms, the current from the battery is the same as it would be if R_1 and R_2 were replaced with a single resistor of 40 ohms.

In Fig. 11, however, we have two separate currents. The battery, of course, has only one current flowing from and back to it, but at the point A this current is able to take either of two paths through R_1 or through R_2, so that the total battery current splits into two parts, which combine again after flowing through the resistors.

An obvious question is, "How much of the total current goes through R_1, and how much through R_2?" The answer is obvious enough, after a little thought, and is that it depends on the values of the two resistors. For example, if R_1 is only 10 ohms, and R_2 is 1000 ohms, we would expect much more current to flow through R_1, and in practice this is found to be the case. If R_1 and R_2 happen to have exactly equal resistances, the current will split into two equal parts, and exactly half of it will flow through R_1 and half through R_2. Where the values are not equal, the way in which the current divides can be quite easily worked out. For instance, if R_1 is 10

ohms, and R_2 is 30 ohms, one-quarter of the total will flow through R_2 and three-quarters through R_1.

It is easily seen, too, that the combination of R_1 and R_2 in parallel could be replaced by a single resistor of some value or other which would allow the same current to flow from the battery, just as with the series case. This single resistance, equal to the combined resistance of R_1 and R_2 in parallel, is not so easily worked out as the series example, but it is obvious that the combined resistance must be **less** than the resistance of either of them. For suppose we disconnect R_2, and a certain current flows through R_1. Then if R_2 is re-connected, more current than before must flow from the battery. This can happen only if the combined resistance is less than that of R_1. There is one case that is quite easily worked out, however, and that is where R_1 and R_2 are equal. In this case, the combined resistance is half the value of each.

(To be continued.)

MR. CORNEY INVESTIGATES

Each month we present a servicing problem all the relevant facts of which will be given by our tame investigator, "Mr. Corney" (with humble apologies to Inspector Hornley of BBC fame). Readers are invited to solve the problems and submit their ideas to our office, marking the envelope "Problem" in the top left-hand corner. Correct solutions will be given in each succeeding issue, together with the names of those whose efforts were successful.

No. 1. THE CASE OF THE VANISHING SIGNALS

Williams came in this morning looking real peeved and humping his pet radio set which "never let him down." Well, it had this time, good and proper—and, of course, just as he particularly wanted it for a special broadcast that evening! Symptoms? Oh, just the usual "off the air" and dead as mutton. We gave it a once over and everything looked jake—he's fussy about his set and keeps it as clean as a new pin, bless him! All the valves checked up so we got busy with the sig-genny and found the LF section lively as a cricket, so we transferred to the FC stage and pumped in some hot IF—nothing doing. Williams looked a bit glum but perked up when we connected to the IF valve and got signals through O.K. That narrowed matters down a lot and with a "I've got it" air I took resistance readings of the first IF coil for open circuit, but got a bit of a jolt when they showed up correct! Voltage checks also proved everything was according to Hoyle. That finished Williams and he oozed off to drown his woes, saying he would call again later—which he did, and went off triumphant humping his pet radio set with him.

The trouble? I'll tell you later as I see old Brown tacking this way with what looks like a load of bother—what a life!

Any attempted solution should be posted so as to reach our offices not later than the 15th of the current month.

The N.Z. Electronics Institute

Meetings for 1947 opened at Auckland with the election of a local committee, and the arrangement of meetings for the year. The first address on "Automatic Telephone Exchange Circuits" is to be given by Mr. S. J. MacDonald, B.Sc., A.M.I.E.E.

At a meeting of the Dunedin Branch of the Institute held at the Physics Department, University of Otago, Mr. J. S. Coombs addressed members on the subject "Frequency Comparisons."

In his opening remarks, Mr. Coombs explained that there were two types of Frequency Standards—namely, Primary and Secondary; and he defined Frequency as the number of cycles in a measured interval of time. Hence the calibration of a primary standard involves two measurements—the number of cycles that occurs in a given time interval, and the measurement of the time.

In outlining the improvements effected over a period from the 1920's to 1945, he quoted examples as follows:—

In 1925 an accuracy of 1000 in 1,000,000.
By 1929 an accuracy of 60 in 1,000,000.
1930 an accuracy of 15 in 1,000,000.
1932 an accuracy of 0.1 in 1,000,000.
1935 an accuracy of 0.02 in 1,000,000 or 2 in 10^8.
1945 an accuracy of 0.01 in 1,000,000 or 1 in 10^8.

At first, the difficulty had been to count the number of cycles—the astronomer could provide an accurate measurement of the time interval. However, electronics has now provided methods of accurately counting cycles, and the present limitation in frequency determination is in measuring the time interval.

By means of a transit instrument, the astronomer can determine the beginning of a day to within 0.01 second. Since there are approximately 100,000 seconds in a day, the astronomer can measure the interval of a day with an accuracy of 1 in 10^7. To measure a time interval to within 1 in 10^8, it is necessary to time 10 days. To determine an oscillator frequency with an accuracy of 1 in 10^8, it is necessary to count the number of cycles that occurs in an interval of 10 days as determined by the astronomer. The value found would be the average frequency of the oscillator during the period. To guarantee that the oscillator frequency is stable, it is normal in Primary Frequency Standards to use systems of oscillators in groups of three, each being self-contained. These oscillators which might be called A, B, and C, nominally generate equal numbers of cycles per second. By comparing A with B, B with C, and C with A, it is possible to detect changes in frequency, unless it happens that all three oscillators change at the same time by the same amount. This is most unlikely, and hence it is possible to test and check the stabilities of the oscillators. It has been noticed on occasions that primary crystal oscillators have apparently produced the wrong number of oscillations in a day. This has been due to a slight change in the rotation of the earth.

(Continued on page 48.)

The Service Section

PRACTICAL TROUBLE-SHOOTING

By C. R. LESLIE, late Technical Officer, Royal Aircraft Establishment

SYSTEM IN PRACTICAL PROCEDURE PART II (Continued)

The next step is to check the R.F. section by using the R.F. signal generator with internal A.F. modulation. First connect the generator leads across the signal-grid of the 6A8 valve and earth, and tune the generator to the intermediate frequency, 465 kc/sec. The main tuning condenser should be at minimum capacity, and the volume control full on. If no response is obtained from the speaker, gradually increase the generator output up to maximum, although, if there is still no response before this is reached, it is pretty obvious that there is a serious defect somewhere. So now we detach the generator lead and apply it at the detector pin of the 6Q7 (point E). If nothing is heard, it must be due to a defect in the detector circuit; either an open circuit in the volume control or its connection, or a shorted H.F. filter condenser (0.0001 mf.) between the I.F. secondary and cathode.

Next, inject the I.F. signal at the grid of the 6K7 (top cap), and if there is nothing doing examine this stage in detail in a similar way. However, instead of taking voltage readings, we could replace the valve with a new one, but if this expedient fails we shall have to resort to the voltage readings again. It is possible, of course, that the I.F. transformer is so off tune in both windings that amplification is insufficient to pass the signal on. This can be checked by altering the tuning of the signal generator each side of the stipulated frequency. If this fails, we can test the windings for continuity with an ohmmeter. This may show up a high-resistance winding. One winding may read at about 8 ohms and the other at some 150 ohms; this defect would not make the receiver inoperative, but would definitely flatten the tuning of the winding and cause distortion of the modulated signals.

When this stage is operative, we inject the I.F. signal at the signal grid of the 6A8 again, and if nothing eventuates we must test this stage in detail as before for voltages, short and open circuits, faulty components, and so on. When all is operating correctly, the signal should be heard distinctly with the signal input reduced to a low value. If a signal is at all audible, we can check the tuning of the I.F. transformers by tuning each winding for maximum response, beginning with the last, i.e., the secondary of the second I.F. transformer. Since the couplings are "tight," they have reflective effects on each other. Therefore, after tuning the primary, we must touch up the secondary again, and then the primary once more until optimum adjustments are made. Then tackle the first I.F. transformer in a similar manner. The test meter may be used as an output meter if we switch it to a low (5-volt) A.C. range and connect the leads between the 6V6 anode (point E) and earth with a 2 mf. condenser in series with one lead to block the flow of any D.C. through the meter. As the circuit contains A.V.C., we must either keep the signal input at a very low level so as to avoid bringing the A.V.C. into play, or short the A.V.C. diode plate to earth and so render the A.V.C. system inoperative. Matters should be so arranged that the meter needle is at about the centre of the scale—the most sensitive region—by adjustment of the signal generator output or volume control, or both.

The final stages of checking the oscillator section of the 6A8 stage, the aerial input stage, and the receiver alignment will be dealt with in Part III, where it will be seen that the signal substitution method, apart from localising troubles to a single stage or part of a stage, finishes the job by aligning the whole receiver. After that, we will show how this Radel Five circuit can be tested by the point-to-point system. Although the foregoing description may have seemed to have been rather long, it will be appreciated that the actual practice of the method is reasonably quick and direct, as it is seldom that one will have to chase right through a circuit from start to finish before finding the trouble.

PART III

Part II dealt with signal tracing by the signal substitution method by assuming a "dead" Radel A.C. Broadcast Five receiver, and had reached the oscillator stage. This may be checked by turning the main tuning condenser to minimum capacity and the volume control to full on, and then injecting a 1500 or 1600-kc/sec. modulated signal (whichever is the limiting frequency shown on the tuning dial) from the generator into the grid circuit of the 6A8 valve. Commencing with a low level of generator output, we increase the level gradually up to full output, or until a faint signal is heard. If there is no response, we must check the oscillator for operation. For this purpose we connect the aerial to the signal grid of the 6A8 and turn the tuning condenser to the normal point for a strong local station, and then, from the signal generator, inject this station frequency, plus the I.F. frequency (unmodulated), at full output into the oscillator grid circuit. A slight rocking of the tuning condenser and slight to-and-fro searching with the signal generator should bring in the station, although not at the usual strength because of the low heterodyne voltage supplied by the generator—it is to compensate for this that the strong local station is used.

The hearing of the station will prove that the oscillator was not functioning before. The oscillator must now be checked in detail for correct anode potential, open or short circuits, high-resistance spots and faulty components as before. If, when checking the oscillator coil in a receiver for continuity, it is found that the grid coil shows a resistance of some 60 ohms, it must be assumed that this is faulty. Some coils are wound with resistance wire for greater stability of operation, while other receivers have 30 to 200-ohm resistors in series with the coil for the same purpose. Oscillators can cut out from far too high a level of heterodyne voltage as well

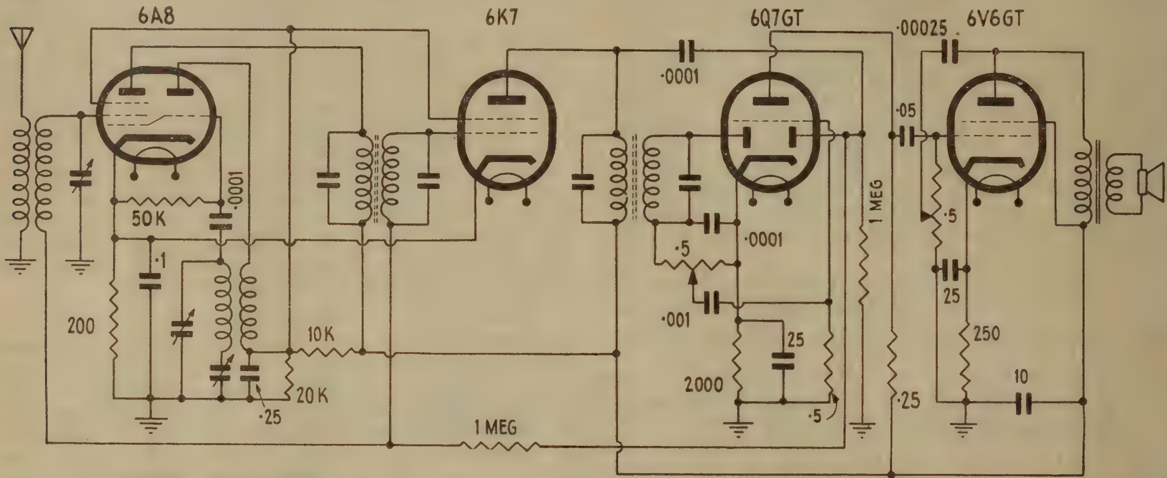
as from too low a level, the excessive volts being more likely to occur at the higher frequencies. The series resistor has a damping influence which is not effective at the lower frequencies, and hence acts as a leveller.

When the fault has been traced and remedied, we can reconnect the generator to the signal grid and check for full operation. While doing this, we may as well line up the circuits, and this can be done with fair accuracy by ear if the speaker output is kept at very low level; the ear can distinguish slight differences at low levels more accurately than at high. Therefore, we turn the tuning condenser to full open and inject the corresponding modulated frequency from the signal generator, keeping its output as low as possible and adjusting the oscillator trimmer for maximum response. Now turn the tuning condenser to 1400 kc/sec. and the generator to the same frequency and adjust the oscillator trimmer exactly. Set the generator to 600 kc/sec. and turn the tuning condenser to this point and adjust the oscillator padder for maximum response. As the adjustment of this series condenser will have an effect on the trimmer, we must return to the 1400 kcs. point again and make a final adjustment of the trimmer—there will be no need to alter the padder again. The tuning can be checked at a mid point as well if desired, that is, at about 1000 kc/sec. If signals of the same loudness are not available here, we must make a slight readjustment of the trimmer and padder to level out the response or slightly deflect the tuning condenser outer split vanes (oscillator section only) till the response is levelled.

The only stage left is the aerial portion, so we inject the 1400 kc/sec. signal from the generator across the aerial and earth terminals. If no response is obtained, even with a fairly strong signal of some 100 microvolts or so, we must check through the aerial input circuit for open or short circuits, faulty coil, and so on. After remedying the defect, we try signal injection again, and on obtaining a response adjust the aerial tuned circuit trimmer for a maximum response in the usual way.

The set is now checked and reasonably lined up, but it is usually found advisable to tune in to a musical or speech programme and reduce the volume to a low but clear level and see whether slight adjustments of the I.F. transformers will improve the quality of the sound. A more exact way of receiver alignment will be dealt with in a later article—the trimming given here is merely mentioned to show that the signal substitution method finishes with this operation and so is a very quick and direct one to use. Ordinarily, faults will not be found in all the stages as suspected in this description—the faulty stage will be quickly located, and the main time will be dissipated in the tracing of the actual defaulter.

Let us now discuss the point-to-point system with the same receiver and see how it parallels with



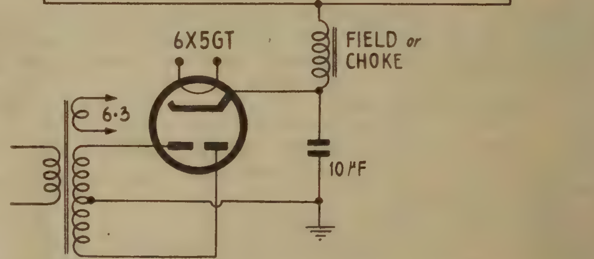


Fig. 1.
Reprint of "Radel Five" circuit which is referred to in the text of this month's instalment.

the other in many respects. The first step is to place the receiver in a condition of maximum sensitivity, i.e., tuning condenser full open, volume full on and no signal, then switch on and allow to thoroughly warm up for some ten minutes. While waiting, prepare a table showing each of the valves and its main electrodes (anodes, screen-grids, and cathodes), and also a column for rectifier supply and H.T. supply to the main set, i.e., after the field choke. If the method is to be generally used, it would be worth while having forms printed with spaces for some twelve valves, and columns for voltages and currents.

Now clamp the negative lead of the D.C. volts section of the test meter to the chassis and touch the positive lead to the various critical points in the circuit, noting down the results in the appropriate place in the form as they are read off. These may be taken in the following order: The rectifier supply (Fig. 1, which is reproduced here for conveni-

ence), the H.T. supply to the set or the screen-grid of the 6V6, then the 6V6 anode voltage, the 6Q7 anode voltage, and lastly the screen and anode potentials of the 6K7 and the 6A8. The meter should be switched to the 500-volt range for these readings. Then reduce the range to some 25 volts and touch the positive lead to the cathodes of the valves and so obtain the bias voltages. The readings should then be compared with the manufacturer's data if available or judged from what we could reasonably expect them to be. Any abnormalities will point to a faulty stage, which can be examined in detail on similar lines to those already mentioned.

SIGNIFICANCE OF VOLTAGE READINGS

But let us first consider the general significance of such readings. Suppose all the voltages were below normal, then the inference is that either the rectifier, the 6X5, is not doing its stuff, or that the mains supply voltage is down. First check the mains supply to the primary of the mains transformer, using the 500v. A.C. range; if this is below normal, it is probably due to bad regulation. A well-regulated mains supply should not vary by more than ± 4 per cent., but in some localities the supply may be a considerable distance away, and then the regulation is likely to be poor or indifferent.

If the supply is reasonable, check the A.C. voltage across the H.T. secondary of the mains transformer; this can be done across the two anodes of the rectifier on the 1000-volt A.C. range, or by separately checking the two halves to earth. These two readings should be very approximately the same if the transformer is well designed—in this receiver we should expect a voltage of 325-0-325 with a 230-volt input, with more or less in proportion to the variation in the supply. Supposing we obtain adequate voltage here, then we should check the heater voltage of the 6X5 for 6.3 volts A.C. Low heater voltage would reduce the emission of the rectifier and hence the supply to the whole set. If the heater voltage is correct, then the rectifier should be replaced. It is possible with this circuit that the rectified voltage will reach the normal level and then practically die away due to a breakdown in the heater-cathode insulation. The 6X5 is constructed to withstand 400 volts between heater and cathode, and with a condenser input filter the rectified voltage

should be in the neighbourhood of 360 volts. It is usually better to have a separate winding on the transformer for the rectifier heater for this reason, the winding being left "floating" as regards potential, i.e., with neither limb nor centre tap being connected to earth.

If the rectifier is absolved from blame by this substitution, we can check the smoothing condensers for excessive leakage, as this would also lower the voltage supply to the set owing to the heavy current drain.

PLATE VOLTAGE READINGS

Now with regard to valve readings: with triodes, a high anode voltage usually results in a high anode current, so that in such cases the current should be metered, and if a low current is found the reason will have to be sought by checking the heater voltage, valve emission goodness, and circuit components, especially leaky H.T. by-pass condensers. With pentodes, the circumstances are different, in that anode voltage has not much effect on anode current. However, the anode current is critically affected by the screen-grid potential, the higher this potential the greater the anode current, so that the correct adjustment of the screen potentials relative to the anode potentials is important—they can be checked against valve manual data.

With this receiver we have no manufacturer's data, so we must estimate what we should expect to read with, say, a 230-volt mains supply. The 6A8 will account for 3.5 ma. anode current, 2.7 ma. screen current, and 4 ma. oscillator grid current—a total of 10.2 ma. The 6K7 takes 10.5 ma. anode current and 2.6 ma. screen current—total, 13.1 ma. The 6Q7 will probably take about 0.8 ma. because of the 250,000-ohm resistor load. The 6V6 takes 34 ma. anode current and 2.2. ma. screen current—total, 36.2 ma. The valves as a whole will then take 60.3 ma., according to valve manual data. The two smoothing condensers will pass a further 5 ma., and the 10,000 plus 20,000-ohm potentiometer for the screens of the 6A8 and 6K7 will pass a further 8 ma. for a 250-volt H.T. supply. This will give a total consumption of 73 ma. for the set. This estimate is rather more than we shall get in actual practice, as the valves will not be working flat out. The probable practical consumption will be about 60 ma. The speaker field of 2000 ohms will drop 120 volts. The rectifier should supply some 360 volts of H.T., so that the supply to the set at the point B should be about 240 volts, or perhaps a little more.

With this as a base we can estimate the rest. The 6V6 screen reading should be that of the H.T. supply, while the anode will drop some 15 volts through the 500-ohm D.C. resistance of the primary of the output transformer, and the bias should be about 13 volts. The 6Q7 should have an anode potential of 50/60 volts, with a cathode voltage of 1.6 to 1.8 (assuming an anode current of about 0.8 ma.). The 6K7 and 6A8 should have anode potentials at approximately H.T. level because the D.C. resistance of the I.F. coils is very small, and the screen potentials should then be 95/100 volts, with cathode voltages of about —3. These figures will serve as a guide to the ORDER of the readings to be expected, and any wide deviations would call for detailed examination. When faults have been remedied and the receiver is re-aligned and working at its optimum efficiency, it would be advisable to take fresh readings of voltages and currents for permanent reference.

The difficulty in taking current readings is that circuits have to be broken for meter insertion, and also the meter must be inserted in such a manner as not to upset the normal operation of the stage and cause instability and oscillation. If oscillation is set up, the anode current will fall and so give false readings. Therefore, as a general rule, it is advisable to insert the meter on the H.T. side of the anode loads, for instance, between the I.F. primary and the H.T. line. Instability is less likely to be caused in the L.F. section of the receiver, and the meter can be inserted at the anode of the 6V6 without compunction if this makes for the easiest connection. If it is found that the meter insertion in the R.F. stages does cause oscillation, we can detune the stage by connecting a condenser of about .001 mfd. across the grid circuit.

The use of current reading makes a valuable check on the performance of the oscillator. In our circuit it will be seen that the 10,000-ohm resistor is common to the screen-grids of the 6A8 and the 6K7 and also to the oscillator anode. The meter can be inserted at the H.T. end of the resistor, and will then read the sum of the steady current in the potentiometer chain (10,000 plus 20,000 ohms), the screen currents of the two valves, and the oscillator current. If the oscillator grid is now shorted to cathode, oscillation will cease and the current reading should rise some 3-4 ma., and regain its former level on removing the short. Alternatively, we could insert the meter between the earthy end of the oscillator anode coil and the junction of the 10,000 and 20,000-ohm resistors; it would then only read the oscillator anode current. Reading the oscillation action by connecting a voltmeter across the 6A8 bias resistor (200 ohms) would not be so sensitive as the rise on non-oscillation would only be a fraction of a volt.

Let us now consider the individual significance of certain readings beyond the obvious ones of zero volts due to open circuits. Suppose the cathode reading of the 6V6 was much less than 13 volts—either the valve emission is badly down or the electrolytic by-pass condenser is leaking and so forming a low resistance in parallel with the bias resistance. If the cathode voltage is much too high, it points to excessive drain from the anode circuit and this may be due to a leaky tone control condenser (.00025 mfd.) or to a leaky coupler (.05 mfd.). A high-resistance leak in either of these components will cause a current to flow through the grid-leak potentiometer and thus make the grid positive to earth by some 8 or 9 volts and thus reduce the effective bias to 5 or 4 volts. This bias would be so low that the grid could easily be swung positive, and so take grid current sufficiently seriously to damage the valve. These two resistors should be of the best quality and capable of withstanding high voltage. When replacing output valves that are down, it is advisable to check up on the coupling condenser to make sure that it is perfectly sound, or, if there is any doubt at all, replace the coupler with a really high voltage sound component. The condenser can be checked in various ways, such as charging it up from a high D.C. source and allowing it to stand for half an hour or so and then shorting the terminals to obtain a spark, which would show that the condenser had retained its charge. This is

a very rough test, and hardly to be depended upon for this unit; a better test can be made with a Megger, if available, or by inserting it in series with a neon tube and a high D.C. source. The H.T. supply must be above the striking voltage of the neon. Two neons could be used in series for an even higher voltage test. On closing the circuit the neon will flash as the condenser charges up and then go out. If there is any leakage of current through the condenser, the neon will continue to glow, even if only faintly. No initial glow indicates an open-circuited condenser. Resistance tests are of no use, as a good condenser will have a D.C. resistance of more than 100 megohms.

Similarly, coupling condensers can upset operation in the R.F. section, though here they are not likely to cause valve damage owing to the normal low emission of the valve and also because grid swings are not likely to be so large. Mica dielectric condensers should be used in such positions wherever possible.

The coupler to the grid of the 6Q7—the .001 mfd, condenser—only has to withstand a low voltage and is not likely to leak except through faulty manufacture, but if it should, the effect will be to reduce the bias on the grid in a similar manner. If the .0001 mfd, coupler to the A.V.C. diode were to leak, it would reduce the delay voltage and the effective bias values of the first two valves.

A leaky by-pass condenser common to the screens of the first two valves (0.25 mfd.) will lower the value of the 20,000-ohm resistor and upset the screen potential setting, lowering it to too low a value.

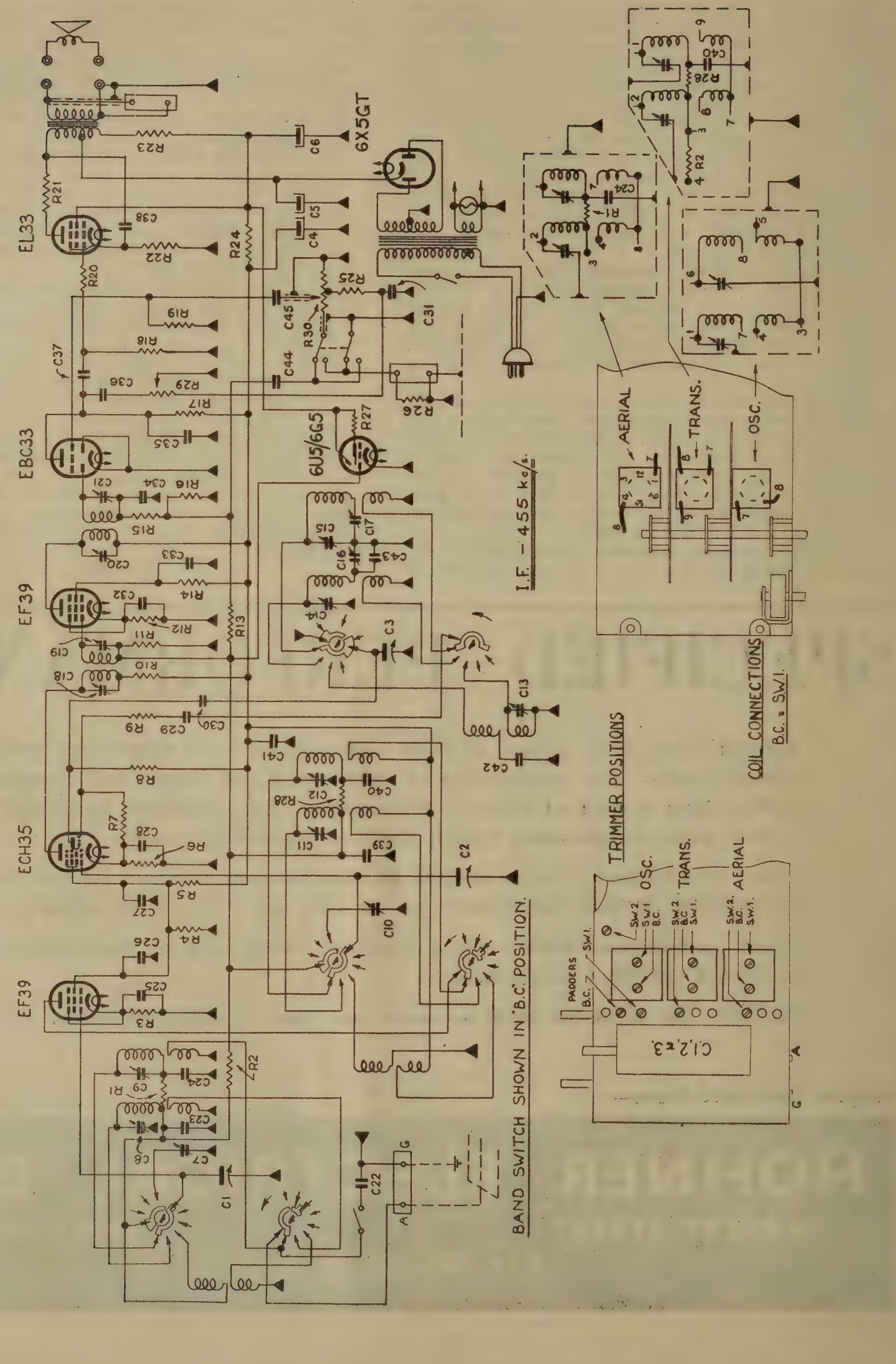
We may briefly summarise the procedure for fault location by either of the above methods thus:—

(1) Remove the chassis, clean it, and inspect the components.
(2) Check the supply end for safety of plugging in.
(3) Check the speaker for functioning.
(4a) Check the L.F. section for operation by signal injection, and then the R.F. section, and then check whichever section is inoperative stage by stage.
(4b) Check the supply to the set from the rectifier, and follow this with a voltage check through the receiver and compare the readings.
(5) On location of the faulty stage by either method, investigate the stage in detail.
(6) Remedy defects and try whole circuit for operation.
(7) Check the alignment.
(8) Place the receiver on a running test for at least four hours.

In next month's article we will consider various methods for the accurate alignment of straight and super-het. receivers by the employment of a meter or an oscilloscope.

(To be continued)

PHILIPS RADIOPLAYER — MODEL 594



Component List for Philips Radioplayer — Model 594

RESISTORS

R1	100,000 Ohm.	1/3 Watt	R12	330 Ohm.	½ Watt	R21	56 Ohm.	1/3 Watt
R2	100,000 Ohm.	1/3 Watt	R13	2.2 Megohm.	1/3 Watt	R22	150 Ohm.	2 Watt
R3	330 Ohm.	1/3 Watt	R14	68,000 Ohm.	1/3 Watt	R23	1,800 Ohm.	2 Watt
R4	27,000 Ohm.	1/3 Watt	R15	47,000 Ohm.	1/3 Watt	R24	2,200 Ohm.	1 Watt
R5	15,000 Ohm.	1 Watt			In I.F. Can	R25	56,000 Ohm.	1/3 Watt
R6	180 Ohm.	1/3 Watt	R16	270,000 Ohm.	1/3 Watt	R26	220,000 Ohm.	1/3 Watt
R7	47,000 Ohm.	1/3 Watt			In I.F. Can	R27	1 Megohm.	1/3 Watt
R8	27,000 Ohm.	1/3 Watt	R17	220,000 Ohm.	1/3 Watt	R28	100,000 Ohm.	1/3 Watt
R9	18 Ohm.	1/3 Watt	R18	47,000 Ohm.	1/3 Watt	R29	600,000 Ohm.	T.C. Pot.
R10	1,000 Ohm.	1/3 Watt	R19	15 Megohm.	1/3 Watt	R30	2 Megohm.	V.C. Pot. with Sw.
R11	2.2 Megohm.	1/3 Watt	R20	1,000 Ohm.	1/3 Watt			

CONDENSERS

C1	Condenser	3-Gang		C24	,,	7,000 Mmfd.	Mica
C2	,,	3-Gang		C25	,,	.05 Mfd.	200V.
C3	,,	3-Gang		C26	,,	.05 Mfd.	400V.
C4	,,	20 Mfd.	400V. Electrolytic	C27	,,	.05 Mfd.	400V.
C5	,,	40 Mfd.	400V. Electrolytic	C28	,,	.05 Mfd.	200V.
C6	,,	40 Mfd.	400V. Electrolytic	C29	,,	50 Mmfd.	Mica
C7	,,	Trimmer		C30	,,	100 Mmfd.	Ceramic
C8	,,	,,		C31	,,	.01 Mfd.	400V.
C9	,,	,,		C32	,,	.2 Mfd.	200V.
C10	,,	,,		C33	,,	.05 Mfd.	400V.
C11	,,	,,		C34	,,	100 Mmfd. in I.F.	Can
C12	,,	,,		C35	,,	250 Mmfd.	Mica
C13	,,	,,		C36	,,	.02 Mfd.	400V.
C14	,,	,,		C37	,,	.01 Mfd.	400V.
C15	,,	,,		C38	,,	.002 Mfd.	600V.
C16	,,	,,		C39	,,	.05 Mfd.	200V.
C17	,,	,,		C40	,,	7,000 Mmfd.	Mica
C18	,,	,,		C41	,,	.1 Mfd.	400V.
C19	,,	,,		C42	,,	.004 Mfd.	Mica
C20	,,	,,		C43	,,	1,200 Mmfd.	Mica
C21	,,	,,		C44	,,	.01 Mfd.	400V.
C22	,,	.01 Mfd.	400V.	C45	,,	.002 Mfd.	600V.
C23	,,	.05 Mfd.	200V.				

VOLTAGE TABLE

Valves	Plate	Screen	Cathode	Filament
EF39	175	80	1.75	6.1
	Osc. 65			
ECH35	170	80	1.3	6.1
EF39	175	70	1.5	6.1
EBC33	30	—	—	6.1
EL33	260	220	5.2	6.1
	Target 220			
6U5	25	—	—	6.1
6X5GT	245	—	270	6.1
	per Plate			

The above voltages were measured with a voltmeter of resistance 1,000 ohms per volt. The receiver was switched to the broadcast position, and the tuning condenser was at maximum capacity.

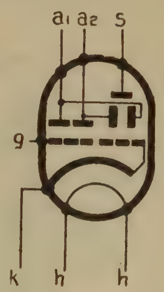
The voltages given are the average of a number of receivers, and may vary slightly from the Table Values.

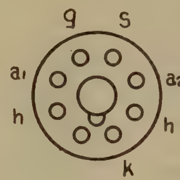
COIL CODE NUMBERS

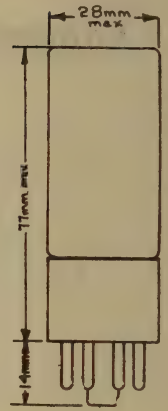
Aerial Coil—BC and SW1	VK 469 31
Translator Coil—BC and SW1	VK 473 06
Oscillator Coil—BC and SW1	VK 471 12
Aerial Coil—SW2	VK 469 32
Translator Coil—SW2	VK 473 07
Oscillator Coil—SW2	VK 471 13
1st I.F. Coil	VK 476 00
2nd I.F. Coil	VK 476 01

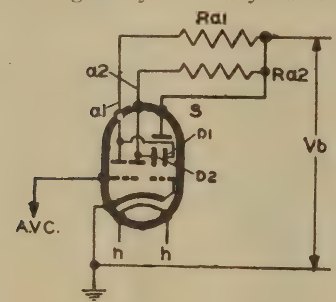
THE EM34 TUNING INDICATOR TUBE

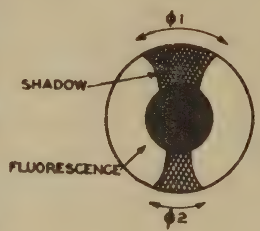
This is a "magic eye" type of tuning indicator, which is unusual in that it has two independently operated shadows, one of which works on weak signals, and the other on strong. The attached circuit diagram shows how the tube works, and how connections are made. The triode section has only one grid connection, but two separate plates, each of which has its own ray control electrode and controls one of the shadows. Each plate is fed by its own dropping resistor. Thus, the only difference in applying this tube as compared with a normal "magic eye" tube is that the extra anode must be supplied by a second dropping resistor. The target voltage may have any value between 100 and 250.











OPERATING CONDITIONS

Plate voltage	100	200	250
Load Resistors (each anode)	1 meg.	1 meg.	1 meg.
Target current	0.2 ma.	0.55 ma.	0.75 ma.
Grid voltage for minimum shadow angle—			
Anode No. 1 ..	—2.5v.	—4.2v.	—5v.
Anode No. 2 ..	—8v.	—12.5v.	—16v.

TRADE WINDS

Sir Archibald Jamieson, Chairman of Vickers, Ltd., arrived in New Zealand last month. Sir Archibald is combining a good deal of pleasure with a little business. While in this country he has met many prominent officials and also the Directors of Messrs. Cory-Wright & Salmon, who are New Zealand agents for Vickers.

Some idea of the vast resources of Vickers may be obtained from the following details:—

During the War, Vickers employed 170,000 people —the wages bill during the period 1939-1944 being £214,000,000.

Altogether, 18 ships were built, including the King George V, Illustrious, Victorious, Indomitable, and S.T. and V.-type submarines. A total of 28,000 aircraft were manufactured, including Spitfires and Wellingtons, and 9000 were repaired. They produced the 12,000 lb. bombs which penetrated the German U-boat pens and sunk the Tirpitz. The 22,000 lb. bombs for the air bombing of Germany were also produced, and a part was played in the breaching of the Mohne and Eder Dams. For the Army, 6200 tanks came from the factories, including Valentines, which were Vickers design. In all, 14,000 guns were manufactured for the Navy, and 150,000 guns for other Services.

The contracts obtained during Vickers reconversion to peace include £18,000,000 merchant shipping, one of the most recent being the "Hinemoa," £10,000,000 orders for commercial aircraft, £8,000,000 for general engineering, £1,000,000 for New Zealand railway wagons, and £20,000,000 for English prefabricated houses.

The Royal Train and the King's Viking Flight for the South African tour were also built by Vickers.

* * *

Mr. Wallace Clarke, of H. W. Clarke, Ltd., Wellington, has returned to New Zealand after a visit to the United States of America and England, the object of which was to make a careful study of the supply position of electrical appliances—in particular, washing-machines and refrigerators.

Mr. Clarke arrived in Britain in time to see the "Britain Can Make It" Exhibition. According to Mr. Clarke, there is little doubt that Britain had given a great deal of thought to the design and manufacture of every type of article, but it was significant that the greater percentage of articles were marked "Not yet available."

The short supply of merchandise can be attributed to three fundamental problems—labour disputes, the passage of time during which Britain had to change from a war to a peace-time production, and the lack of raw materials not produced in Great Britain.

Mr. Clarke was obviously interested in British export from the aspect of the activities of his own organisation, but could receive no assurances from manufacturing executives as to if and when the supply position would improve. In connection with the British manufacture of domestc refrigerators and washing-machines, it is also significant that England has authorised the importation of these appliances from the United States of America.

In the United States, manufacturers are encountering similar problems for the same reasons as in England. In addition to change-over difficulties, manufacturers are seriously troubled by the impossibility of co-ordinating the deliveries of components from the many specialist factories. As an example, one producer of domestic radio receivers who normally carries a stock valued at 3,000,000 dollars, with a production capacity of 5000 receivers a day, finds that, owing to the difficulty experienced in the supply of components, the plant can produce only 900 receivers daily.

From the foregoing, it is obvious that, until smooth overseas production can be obtained, New Zealand cannot look forward to a reasonable stability of supply.

* * *

National Electrical and Engineering Co., Ltd., advise that further limited supplies of the General Electric, U.S.A., Industrial Electronic Tube Manuals have come to hand, and may be obtained on application, the cost being £1 1s. for the manual and 12s. 6d. for the replacement sheet service.

* * *

We have been advised that Green and Cooper Ltd., of Wellington, have made some changes to the future activities of their firm. The P.A. and radio servicing departments of the firm have been taken over by Herb Dixon, who was at one time the original partner with Wally Green.

Green and Cooper will retain and extend their activities in the production of specialised sound equipment in addition to importing, wholesaling and retailing.

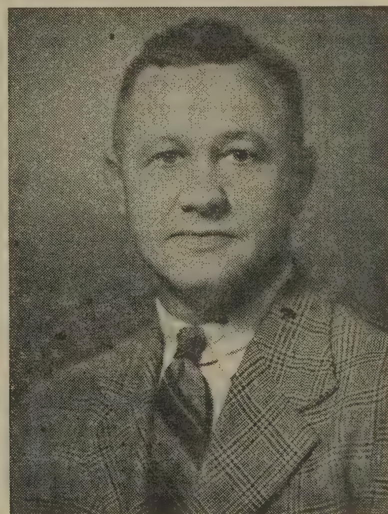
GOSSIP COLUMN

During the past year we have had many requests from readers asking "Who are you," and in response to these we have decided to tell you something about ourselves.

The Manager of "Radio and Electronics" is Stan Shea. Born in Nelson, he was educated at Nelson Boys' College and commenced his radio career at Wilkins and Field, Nelson, in 1926. Until 1937 he was engaged in radio and sound engineering. During the latter part of 1937 he joined Radio Corporation of New Zealand Ltd., with which organisation he remained until 1941 when he joined the R.N.Z.A.F.

S. C. SHEA

W. D. FOSTER

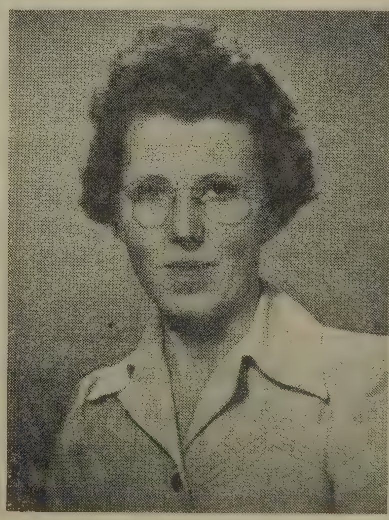


I. S. ROWE

He went overseas almost immediately, and after a course in radar at Yatesbury, he was posted to a radar station near Newcastle. Six months later he was commissioned and posted to the Telecommunications Research Establishment at Malvern. Several months were spent on the development of H_2S, the radar blind bombing equipment, and when this was ready for production he acted as liaison officer for Air Ministry and Bomber Command in the initial installation of the equipment in heavy bombers, and also the fitment into the aircraft while they were still on the production line at the factories. When this work was well under way, he was posted as Radar Staff Officer to Air Vice-Marshal Bennett, A.O.C. of Pathfinder Force. This work involved the introduction of H_2S into the R.A.F. After twelve months' service in P.F.F., he was appointed Deputy Director of Signals (Radar) in the R.N.Z.A.F. with the rank of Squadron Leader, retaining this appointment until his transfer to the Reserve in 1946.

Our Technical Editor is Doug Foster. Educated at Auckland Grammar School, Wellington College, and Napier Boys' High School, he graduated Bachelor of Science from Canterbury University College in 1934. Three years were spent teaching, and in 1938 he received an appointment to the technical staff of the National Broadcasting Service, where he remained until he joined the R.N.Z.A.F. in December, 1940. Posted to England that same month, he received his commission in July, 1941, and after a period as instructor at Yatesbury, Cranwell, and Prestwick Radar Schools, he served on coastal radar stations in England. Late in 1942 he underwent a special course in Operational Research at Fighter Command Headquarters, Stanmore, after which he was posted to New Zealand to take over O.R.S. instituted by C. J. Banwell. Whilst thus occupied he was engaged on many interesting jobs dealing with various aspects of radar and communications, such as work on anomalous propagation at radar frequencies, direction of arrival of waves between U.K. and N.Z., the first field tests of Loran transmitting equipment in New Zealand, and the siting and performance of ground radar installations, etc. This position he retained until 1946 when he was posted to the Reserve.

As Assistant Technical Editor we have Ian Rowe.



MISS D. JAMIESON

Born in Eltham, he was educated at Stratford and Hawera High Schools, after which he joined the R.N.Z.A.F. as a member of the permanent staff, originally training as an engineer. After seven years' experience in this type of work, he transferred to the Signals Branch. His service experience covered many applications of electronics and communications. After installing the original R.N.Z.A.F. C.O.L. radar station at Fiji, he was commissioned in 1943, thereafter being in charge of the installation of T.R.U. radar stations in New Zealand.

In 1944 he was posted to Air Department in charge of maintenance and modification of ground equipment, which position he retained until his release from the service with the rank of Flight Lieutenant in February, 1947.

Miss D. Jamieson, who is engaged in secretarial and editorial work, has been associated with the Signals Branch of Air Department also.

Born in London, Miss Jamieson came to New Zealand during her early years, and was educated at Wellington East Girls' College and Victoria University. After spending four years in the Agricultural Department, she joined the Air Department in August, 1939, as a member of the Cypher Staff, a few months later being appointed to the position of Officer-in-Charge of secret and confidential publications, most of which related to signals and radar. This position she relinquished in June, 1946, when she accepted the appointment to the staff of "Radio and Electronics."

* * *

On calling on H. W. Clarke's the other day, we saw Basil Clarkson looking on top form. Basil saw service with the R.N.Z.A.F., and is now back with the firm as sales representative for the middle north territory of New Zealand. Apparently, he had an excellent holiday at Taupo, with Ken Bottomley of Taumarunui—most of the time being spent fishing and launching.

Bert Staff has recently returned from overseas army service, and after spending a few months in Christchurch he has been transferred to H. W. Clarke's Auckland Branch.

* * *

Mr. T. B. Lockyer, of Napier, has been in Wellington and while here called on a number of radio houses.

* * *

Our congratulations go to "Stewie" Hyde of Shannon—he has been presented with a son.

Methods of Measuring Small Voltages

By the Engineering Division Aerovox Corporation

While, with certain exceptions, the instruments and methods employed for the measurement of small D.C. voltages resemble in most part those employed for checking small A.C. voltages, the two differ sufficiently in close respects to warrant separate discussions.

Since a large number of experimenters will prefer to use particular apparatus already in their possession for low-voltage measurements, this article will attempt to cover most of the commonly used, as well as special equipment.

INSTRUMENTS FOR D.C. MEASUREMENTS

d'Arsonval Meters.—Rugged, movable-coil meters which may be used for small D.C. voltage measurements are available either as D.C. millivoltmeters or D.C. microammeters. The latter type is basically a millivoltmeter, although it is provided with a scale graduated in current units.

In the group of meters obtainable in laboratory-table and panel-mounting styles, the most sensitive movement gives a 1 millivolt full-scale deflection. This movement has a resistance of 5 ohms and draws 200 microamperes at full scale.

Accuracy of indication in the portable meter is 1 per cent., although 2 per cent. of full-scale is common for the panel-mounting instruments used in radio testing. The scales are divided into 50 divisions, each equal to 0.01 mv. or 10 microvolts. The smallest accurately-read deflection is one-half of a division, which is equal to 5 microvolts.

More common than the 0-1 D.C. millivoltmeter is the 0-5 microampere D.C. microammeter. The movement of the latter has a D.C. resistance of approximately 4000 ohms, which indicates that the meter basically is a 0-20 millivolt D.C. millivoltmeter. This instrument has the advantage that it presents a high resistance to the low-voltage source, resulting in reduced loading effects.

The original 0-5-microampere scale may be remarked to indicate 0-20 mv., or a new scale of the same dimensions may be drawn. Each of the 50 scale divisions will be equal to 0.2 mv. (200 microvolts), the smallest accurately read deflection (half scale division) being equal to 0.1 mv. (100 microvolts). This is about the same sensitivity per scale division that may be expected of the small, portable laboratory galvanometers commonly employed as null detectors in D.C. Wheatstone bridges.

Suspension-type Meters. — Ultra-sensitive laboratory microammeters of the semi-suspended type are obtainable with full-scale deflections as low as 0.25 microampere, and may be used for the measurement of small voltages. One well-known 0-0.25 microamp. instrument has an internal resistance of 12,000 ohms. Corresponding full-scale deflection in terms of voltage thus is 3 mv. The smallest accurately-read deflection of this meter (half-scale division) is equal to 12 microvolts.

Another model of the same type instrument is an ultra-sensitive D.C. millivoltmeter having a full-scale deflection of 0.12 mv. The internal resistance of this meter is 10 ohms. The smallest accurately-read deflection (half-scale division) is equal to 0.5 microvolts.

The ultra-sensitive, semi-suspended type of meter usually has an accuracy of 2 per cent. of full scale. However, they are said to exceed their guarantee to the extent of showing 1 per cent. accuracy in most portions of the scale.

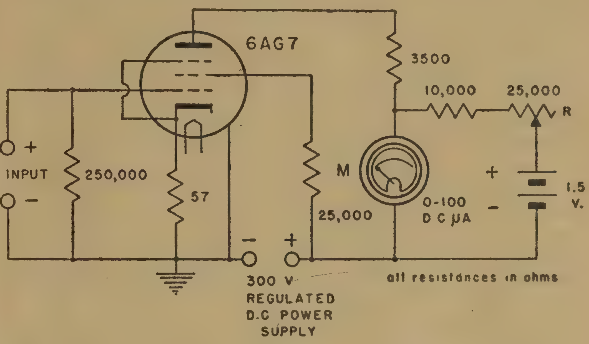


Fig. 1.

Sensitive Laboratory Galvanometers.—Suspension-type laboratory galvanometers of the lamp-and-mirror type are obtainable with sensitivity as good as 0.05 microvolt, per millimetre of deflection (based upon 1 metre separation between the scale and galvanometer mirror). A typical instrument of this rating has a total internal resistance (coil, suspension, and damping resistor) of 26 ohms, and its scale has 500 one-millimetre divisions. Full-scale deflection is 25 microvolts.

When higher internal resistances are required, a selection may be made from other galvanometers of the full suspension type having total internal resistances of the order of 10,000 ohms. One 10,500-ohm instrument gives a deflection of 5.25 microvolts/mm. for a scale-mirror separation of 1 metre.

Because of the relative fragility of the suspension-type of galvanometer, particularly as regards their suspensions, and their extreme susceptibility to the damaging effect of transients, this instrument may be employed safely for the measurement of small voltages only in circuits protected from damaging surges and accidental overload.

Coblenz Galvanometer.—While this instrument is of the lamp-and-mirror type, it differs from the moving-coil type of galvanometer in that it is of the astatic variety, consisting of a moving magnet in iron-encased coils.

The Coblenz galvanometer is more sensitive than moving-coil instruments; one commercial type having a sensitivity of 0.002 microvolt per mm. scale division, for a scale-to-mirror separation of 1 metre, and an internal resistance of 2½ ohms.

D.C. Amplifier.—When necessity or choice dictates use of a more rugged high-range voltmeter for measurement of small D.C. voltages, a suitable D.C. amplifier must be interposed between the meter and the voltage source. An amplifier may be employed in this way to raise voltages of 1 mv. or less to

values high enough to actuate a standard D.C. voltmeter such as is used for ordinary electrical testing, or to deflect a D.C. milliammeter connected into the plate circuit of the last amplifier tube. The amount of amplification required will be governed by the magnitude of the voltage to be measured and the size of the meter scale (full-scale deflection). One stage will suffice in some cases, while in others a multi-stage amplifier will be necessary. Required amplifier gain may be determined simply by dividing the desired voltmeter deflection by the small voltage value. Both values must be in the same class of units, i.e., both volts, millivolts, or microvolts.

A typical high-transconductance, single-stage amplifier with indicating microammeter is shown in Fig. 1. The 6AG7 pentode has a transconductance (Gm) of 11,000, which is to say that a 1-mv. potential (Eg) applied to the grid-cathode INPUT terminals will produce a plate current shift (dI) of 0.011 ma. If meter M is a 0-100 microampere D.C. microammeter, a 9.9-mv. input potential will produce full-scale deflection. The smallest accurately-read deflection (half-scale division) will correspond to 0.198 mv. (198 microvolts) if the microammeter has 50 scale divisions. The ideal plate current change to be expected is seen to be equal to (GmEg)/1000, where the plate current change is in milliamperes, Gm in micromhos, and Eg (the applied "unknown" voltage) in volts.

With no unknown voltage applied to the INPUT terminals, deflection due to static plate current flow is balanced out by adjusting rheostat R to return the microammeter pointer to zero. Instead of the bucking battery, a bridge circuit may be worked out to include the rheostat as one arm and the plate-cathode resistance of the tube as another arm.

Measurement of smaller voltages or use of a larger indicating meter will require higher amplification. Fig. 2 shows the basic arrangement of a multi-stage D.C. amplifier usable for this purpose.

While batteries are shown here for the sake of simplicity, the various tube electrode potentials usually are obtained from taps spaced properly along a voltage divider resistor supplied by a single D.C. power unit. Battery B_1 supplies grid-cathode bias for tube V_1; B_2, screen voltage for V_1; B_2 and B_3 in series, plate voltage for V_1; B_4, grid cathode bias for tube V_2; and B_5, screen voltage for V_2; and B_5 and B_6 in series, plate voltage for V_2. Voltage delivered by B_7 opposes the voltage drop across plate load resistor R_2 resulting from the steady flow of static plate current in V_1, and thereby prevents the control grid of the tube V_2 from being excited constantly by this potential.

When a small D.C. voltage is applied to the input terminals of the multi-stage amplifier, an increase in the plate current of tube V_1 results, if the positive terminal of the unknown voltage source is connected to the grid of V_1. This increased plate current flowing through R_2 produces a voltage drop which is applied to the control grid of V_2 with the proper polarity to cause a plate current increase in the latter tube.

(To be continued.)

This article has been made available by the courtesy of Swan Electric Co.

DESIGN SHEET NO. 4

(Continued from page 26.)

25 c/sec., with increasing attenuation below this point. If this degree of attenuation is adequate, the value of CR is fixed at 0.002. The next step is to decide on the values of C and R to give this product. If the following stage can have a grid leak of 1 meg., then the condenser C will have to be 0.002 mfd. to give the required response curve. If a grid leak of .25 meg. is to be used, C must be 0.008 mfd. Any other values of C and R, which, when multiplied together, give a product of 0.002 will give the required frequency response, so that the exact values can be chosen to suit any other condition that may be imposed. In general, R is made as high as possible, both because this necessitates the smallest condenser, and because doing so helps to increase the gain of the preceding stage. Of course, a maximum value of R is usually set by the valve manufacturers, and this constitutes the upper limit for this component.

The chart is particularly useful where unusual conditions dictate a low value of grid resistor. One such case is that of a 2A3 with fixed bias and resistance coupled to the preceding stage. Now the manufacturers state that the grid resistance under fixed bias conditions should not exceed 50,000 ohms or 0.05 meg., so that R is fixed at this value. The question is: "What is the **minimum** allowable size of coupling condenser that will give a drop of not more than 2 db. at, say, 50 c/sec.?"

Now, from the chart it is seen that a CR of 0.005 gives a drop of 1.5 db. at 50 c/sec., so that this curve may be used for reference. Since R = 0.05, C must equal 0.1 mfd., for the required response curve to be obtained. Since this is a reasonably small value, there would be no hardship in using 0.05 mfd., which would give CR = 0.025, and would give a response curve slightly better than that labelled CR = 0.02, which is much better than the **minimum** specification originally made.

RELEASE OF SURPLUS EQUIPMENT

(Continued from page 14.)

two stages of transformer coupled audio. Transmitter and receiver aerial circuits are separately tuned. R.F. milliameters are provided in both the transmitter and remote aerial coupling unit.

Wireless Set SCR131

Designed for Army field use and transported by means of a two-man pack, the SCR131 is a C.W. transmitter, operating on a frequency band of 3.96 to 4.36 mc/sec. It has an output of 5 watts, is an M.O. circuit, and the power supply is a hand-driven generator giving 10 x 400 volts. The receiver is powered by one 4½v. and one 45v. dry battery. The weights of the units are as follows: Trans-receiver, 22 lb.; hand generator, 20¼ lb.; and the antenna loop, 1⅝ lb. The tubes used are one-type 10 and three-type 864.

DESIGN OF BATTERY OPERATED RECEIVERS

(Continued from page 23.)

The nature of the disturbance created by the increased resistance of the "B" battery has been aptly termed "motor-boating." The "B" batteries form the common source of plate and screen grid voltage for all the tubes in the receiver, and portions of their total resistance are common to two or more of these circuits, depending upon the relative voltages applied to the circuits considered. Variations in the plate current supplied by the batteries to the output tubes, for instance, will cause a simultaneous fluctuation in the plate voltage of every tube in the receiver, due to the varying voltage drop of this current through the battery resistance. The possibilities for regeneration in the system are very great, unless this condition has been recognised in the receiver design and suitable filtering provided.

In a receiver which has not been properly designed in this respect, persistent motor-boating of sufficient intensity to render the receiver useless for broadcast reception will usually occur when the battery resistance has risen to from 25 to 50 ohms per 22½-volt section. The frequency of the oscillation produced in this manner is ordinarily very low, being of the order of 1 to 10 cycles per second.

In studying this condition, it is sufficient to investigate primarily the condition of lowest voltage and highest resistance. Having corrected the design to ensure satisfactory operation at this point, such operation is also ensured at all higher voltages. A "B" potential of 12 volts per 22½-volt section should be chosen for this purpose. The maximum battery resistance of 330 ohms per 22½-volt section, or a total of 1320 ohms per 90-volt battery, is normally used for this work as a result of the measurements previously described. Obviously, the engineer should not work too closely in the design of his filters, but should allow a reasonable factor of safety in this regard. It is good practice to provide for operation with a 25 to 50 per cent. overage in the resistance value, the added cost for this insurance against higher resistances usually being negligible.

To provide a suitable voltage supply for this investigation, it is necessary to obtain a set of "B" batteries which have been discharged on radio service to the voltage desired, or else to use an arrangement simulating discharged batteries. This may be done by tapping fresh batteries and inserting suitable values of external resistance. It is not sufficient to reduce the voltage of fresh batteries by rapid discharge, since the resistance of a battery discharged to low voltages in this manner is not as high as that of one normally discharged over a long period of time.

In simulating a discharged battery, it is important that the following points be kept in mind. First, only fresh batteries should be employed, their resistance being negligible. Second, the resistance added must be distributed between the battery taps in proportion to the respective voltages if intermediate voltage taps are used. If all of the resistance is added on the negative end of the battery, where it is common to every "B" circuit, the results will not be the same as those obtained by a proportional distribution of the resistance between taps, if such taps are used in actual service. Lumping all the resistance in a single unit is only permissible in those cases where all "B" circuits are supplied with the battery voltage. Third, readings of battery voltage should be taken only under load and should be taken across the terminals of the battery cables so as to include the voltage drop of the load current through the added resistance.

Having such a "B" power source available, it is a relatively simple matter to determine whether the receiver under investigation will give satisfactory operation throughout the entire useful life of the batteries. If oscillation is encountered, the critical circuits may be isolated and suitable filtering provided. A convenient means of accomplishing this isolation is to provide each circuit or combination of circuits in turn with a separate source of "B" power, the disappearance of the oscillation indicating the isolation of the critical circuit. Each set design presents an individual problem in this respect, although the use of a large capacity electrolytic condenser will suffice in a large number of cases.

It is highly desirable that the engineer use an "on-off" switch arrangement which will remove the "B" voltage during periods of receiver idleness, so that this voltage will not be constantly impressed across circuit components such as transformers, chokes, condensers, and resistors, and so hasten their failure due to electrolysis through leakage to ground in damp weather.

ELECTRONICS INSTITUTE

(Continued from page 32.)

Once a Primary Frequency Standard has been calibrated, Secondary Frequency Standards or other oscillators can be calibrated by comparison with the primary frequency standard.

Mr. Coombs demonstrated two methods of comparing frequencies, using two Audio Oscillators. The first method, an aural one, depended on the production of a beat wave-motion and the recognition of the zero beat condition; the second method depended on recognising Lissajou's figures on an Oscilloscope.

A description was given of the Secondary Frequency Standard constructed and used by the University Physics Department. It used a master oscillator of 100 kc/s, together with a series of multivibrators to provide signals of other frequencies. A block diagram was outlined of the train of buffers, distortion amplifiers, multivibrators and filters which were incorporated in the standard. The Frequency Standard is calibrated by comparing its frequency with that of the carrier of 4YA, nominally 790,000 cycles per second. Actually, 4YA's carrier is low by 16 c/s, as checked by Makara Radio, which uses signals propagated by WWV in U.S.A. as its standard. By tuning in the carrier of 4YA, selecting the 79th harmonic of the 10 kc/s signal from the Standard, and injecting these into the mixer and adjusting for zero beat, an accuracy of the order of 1 in 100,000 can be achieved.

Next, Mr. Coombs explained the theory and the action of a multivibrator, and demonstrated one method of locking the frequency of a multivibrator to a sub-multiple of an injected frequency.

A practical demonstration with the Frequency Standard and other equipment was conducted in the Experimental Laboratory. The frequency of a valve-maintained tuning fork was measured, the method of calibrating an audio oscillator using Lissajou's figures was demonstrated, and 1 mc/s crystal oscillator was adjusted to within 0.5 per cent. of its normal frequency by making a comparison with WWV using a communications receiver.

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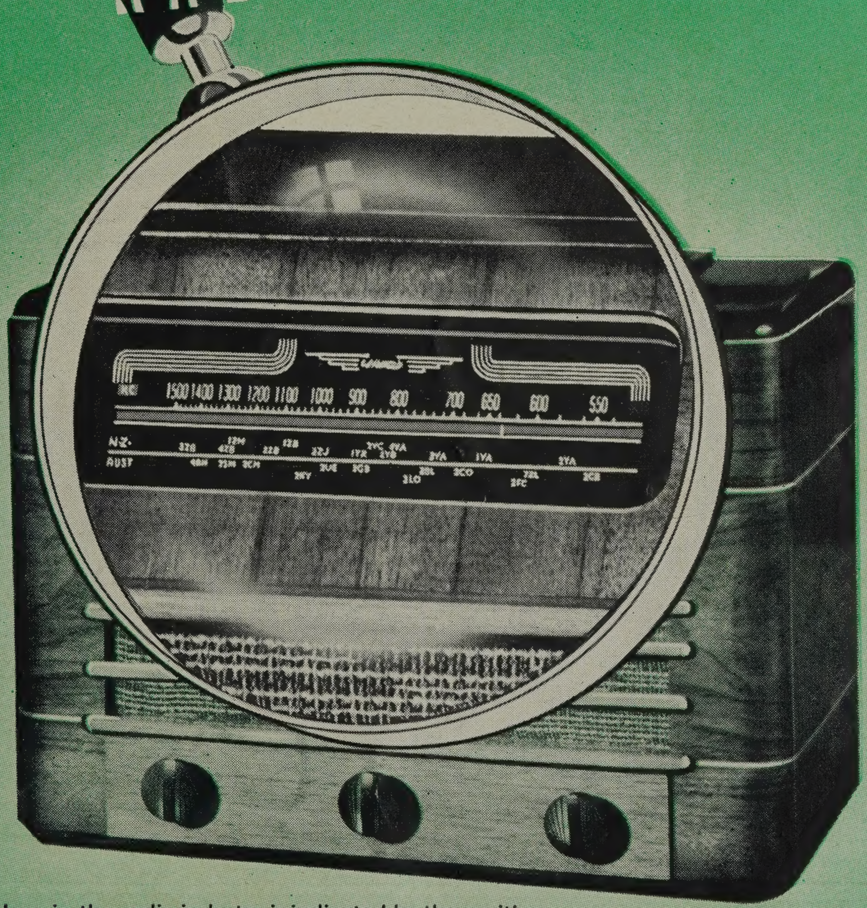
OUR PLACE IN THE RADIO INDUSTRY



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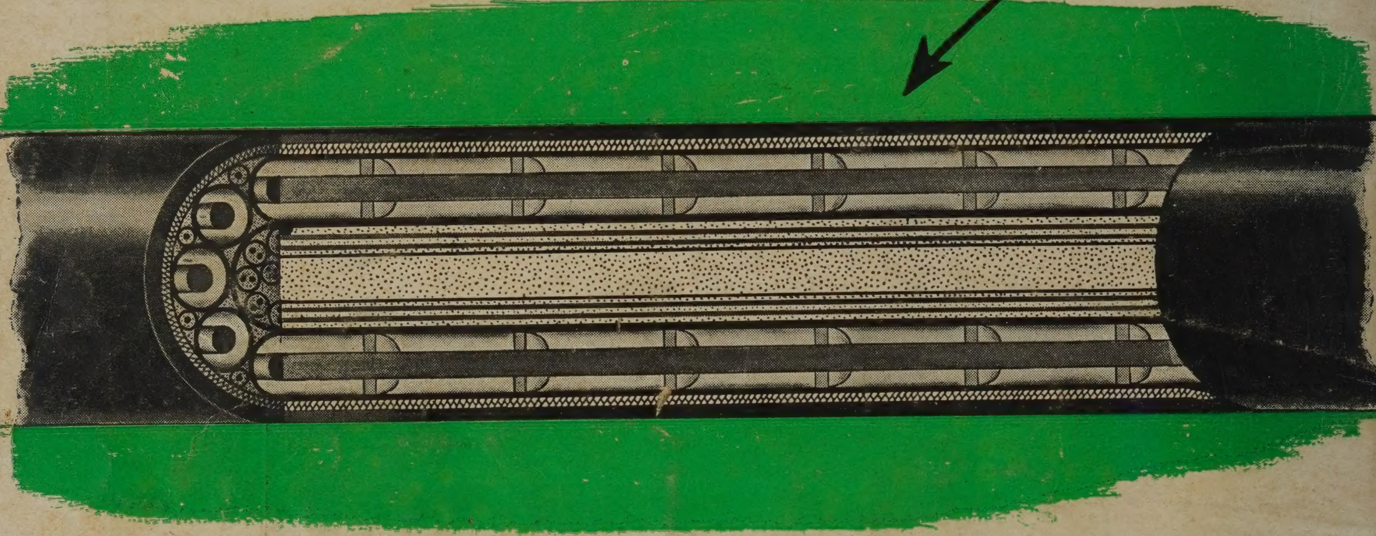

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